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(NASA CR-51423) **SM2A-07-BP 12**

NASA
SUPPORT MANUAL

APOLLO 51
SPACECRAFT DESCRIPTION MANUAL
HIGH DYNAMIC PRESSURE ABORT (U)

(TITLE UNCLASSIFIED)

(NASA Contract No. NAS9-150)

Exhibit I; Paragraph 10.3

(Applicable to Boilerplate 12 Only)

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SECTION I

INTRODUCTION

1-1. PURPOSE.

1-2. This manual provides a description of the boilerplate spacecraft configuration used for the high dynamic pressure abort test. (See figure 1-1.) Boilerplate modules economically simulate flight rated modules for test purposes, incorporating only the structures and systems required for a particular test. These modules are combined to form spacecraft configurations for selected tests. Each spacecraft configuration is described in a separate manual.

1-3. SCOPE OF MANUAL.

1-4. A physical description of the overall spacecraft and its major components (modules) is provided in illustrative, textual, and tabular forms. System operation is described in text, tables, and diagrams. Sufficient detail is provided to identify the configuration of the flight test article and to differentiate it from spacecraft used in subsequent flight tests. This manual is system oriented with emphasis on system configurations intended for use in ultimate spacecraft (flight-rated systems). Research and development (R&D) systems are treated in gross terms, and, in the case of customer furnished equipment, reference is made to customer documents for detailed information. Two of the flight rated systems, the launch escape system and the earth landing system, are used in boilerplate 12. The operations of these systems are covered in separate sections of this manual.

1-5. ARRANGEMENT OF MANUAL.

1-6. This manual is divided into four sections. This section contains information relative to the manual only and includes references to supplementary documents. Section II contains a physical description of the complete flight test article and operational descriptions of equipment other than the launch escape system (LES) and earth landing system (ELS). A brief description of the launch vehicle, Little Joe II, is included. Sections III and IV provide an operational description of the launch escape system and the earth landing system, respectively.

1-7. SUPPLEMENTARY INFORMATION.

1-8. Table 1-1 is a list of documents containing supplementary information for boilerplate 12.

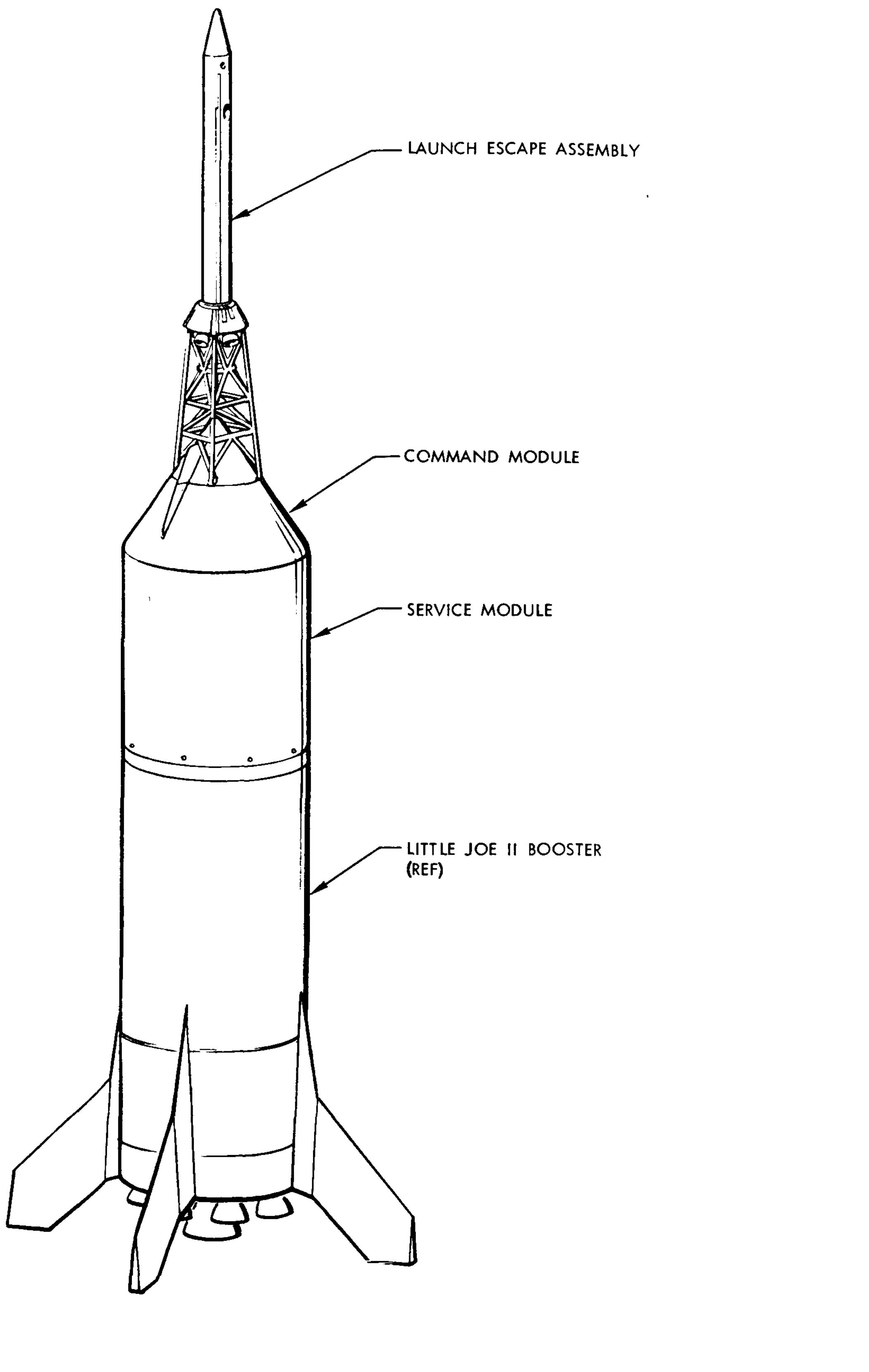


Figure 1-1. High Dynamic Pressure Abort Test Vehicle

Table 1-1. Supplementary Documents

Number	Title	Contents
SM2A-02	Spacecraft Familiarization	Description of all spacecraft systems in gross terms
SM2A-05	Transportation and Handling Procedures	Instructions for handling, packaging, packing, shipping, transporting, and storing the Apollo spacecraft for boilerplate 12 and its associated ground support equipment
SM3A-201	Transportation and Handling Equipment Maintenance Data Sheets	Maintenance procedures for transportation and handling equipment
SM3A-202	Auxiliary, Checkout, and Servicing Equipment Maintenance Data Sheets	Contains maintenance instructions in data-sheet form for noncomplex end-item equipment
SM3A-203	Command Module Substitute Unit, Model A14-002	Instructions for field level maintenance of the equipment. Interfaces with GSE electrical checkout equipment for checkout of the command module intermodule system
SM3A-205	Radar Transponder and Recovery Beacon Checkout Unit, Model C14-112	Physical and functional descriptions and maintenance procedures consisting of functional tests and repairs
SM3A-215	Data Recording Group, Model C14-020, and Signal Conditioner Console, Model C14-135	Physical and functional descriptions and maintenance procedures consisting of functional tests and repairs

Table 1-1. Supplementary Documents (Cont)

Number	Title	Contents
SM4A-201	Launch Escape System Maintenance	Maintenance procedures for the launch escape system consisting of trouble analysis, repair, removal and installation, and calibration and adjustment as related to boilerplate 12 configuration
SM4A-207	Earth Landing System Maintenance	Maintenance procedures for the earth landing system, consisting of trouble analysis, repair, removal and installation, and calibration and adjustment as related to boilerplate 12 configuration
10.1	Apollo R & D Instrumentation Communications Systems Familiarization Manual (NASA)	Familiarization data for government furnished R & D communications and instrumentation for flight test spacecraft
11.1	Apollo R & D Instrumentation System B/P 12 Description Manual (NASA)	Physical and operational descriptions of instrumentation employed with boilerplate 12
14.1	Apollo R & D Instrumentation System B/P 12 Checkout Manual	Step-by-step checkout procedure to be accomplished for government furnished instrumentation installed in boilerplate 12

SECTION II

OVERALL SPACECRAFT

2-1. PURPOSE OF BOILERPLATE 12 CONFIGURATION.

2-2. A high dynamic pressure abort or max "q" abort is an emergency condition occurring during the initial stages of launch when dynamic pressures on the command module and launch escape tower are at their peak. The command module and crew must be removed from the vicinity of the launch vehicle in the minimum amount of time. The unmanned boilerplate 12 flight test configuration and the Little Joe II launch vehicle simulate the launch condition.

2-3. FIRST ORDER TEST OBJECTIVES.

2-4. The following are the primary objectives of the boilerplate 12 flight test spacecraft:

a. To determine aerodynamic stability characteristics of the Apollo escape configuration during a high dynamic pressure abort

b. To demonstrate the capability of the escape system to propel the command module to a safe distance from the launch vehicle after a high dynamic pressure abort

c. To demonstrate the structural integrity of the escape tower during a high dynamic pressure abort

d. Demonstrate proper operation of the command module to service module separation mechanism

e. To demonstrate the parachute recovery system

2-5. SECOND ORDER TEST OBJECTIVES.

2-6. The following are the secondary objectives of the boilerplate 12 flight test spacecraft:

a. To determine aerodynamic loads due to fluctuating pressures on a simulated spacecraft during a Little Joe II launch

b. To demonstrate Little Joe II spacecraft compatibility

c. Demonstrate satisfactory abort and recovery timing sequence

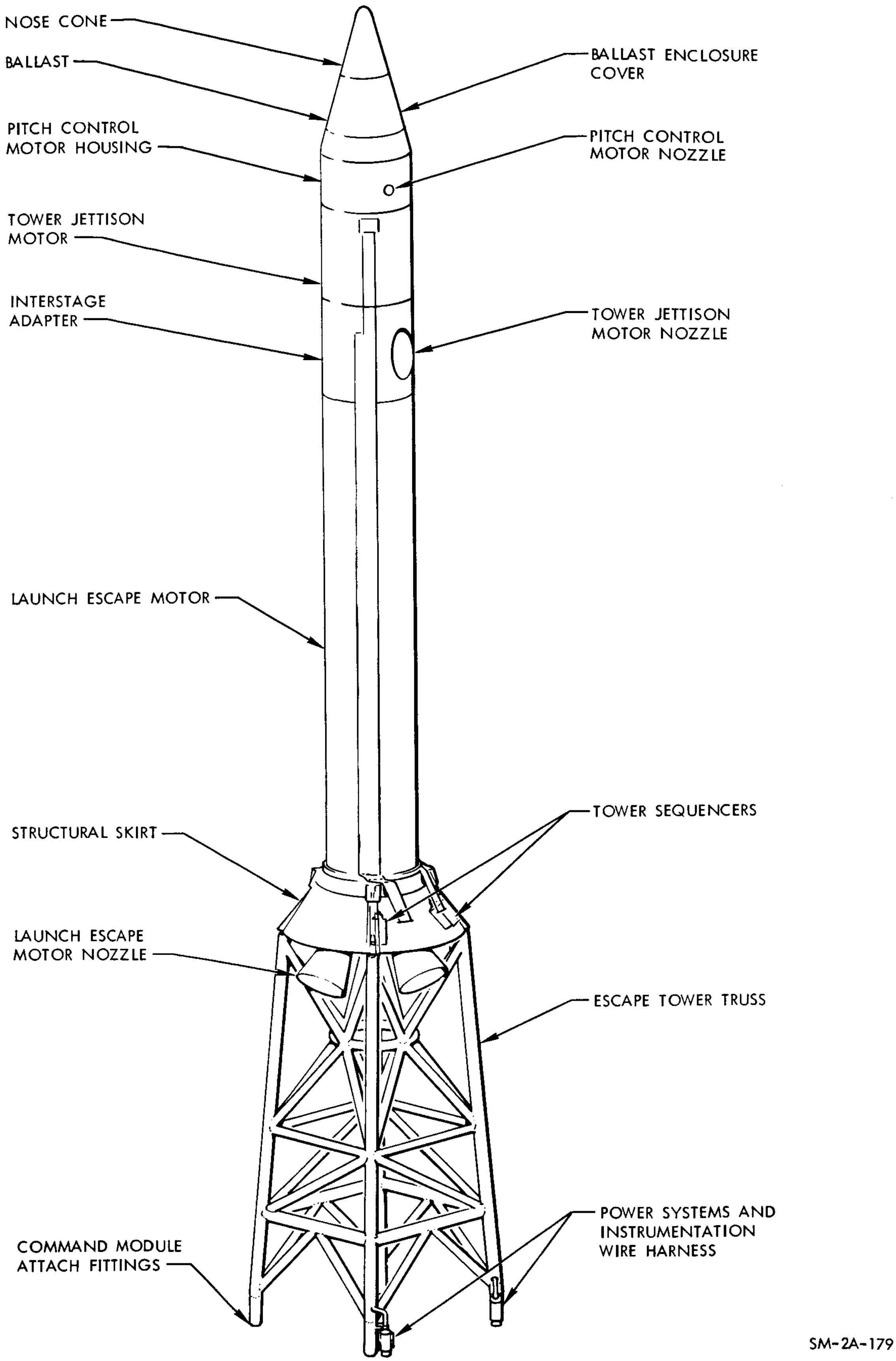


Figure 2-1. Launch Escape Assembly

2-7. PHYSICAL DESCRIPTION.

2-8. The boilerplate 12 configuration consists of a launch escape assembly, a command module, a simulated service module, and a spacecraft adapter. The boilerplate 12 spacecraft mounted on a Little Joe II booster rocket is the complete high dynamic pressure abort test vehicle. (See figure 1-1.)

2-9. LAUNCH ESCAPE ASSEMBLY.

2-10. The structural relationship and physical location of the components of the launch escape assembly are shown in figure 2-1. Pertinent physical characteristics are contained in table 2-1.

Table 2-1. Launch Escape Assembly Physical Characteristics

Overall Dimensions	
Length	33 feet
Weight (nominal)	6410 pounds
Major Components	
Tower structure	
Length	118 inches
Width, top of tower	36 inches
Width, bottom of tower	50.6 inches
Weight	352 pounds
Structural skirt	
Length	18.25 inches
Diameter	48.8 inches
Weight	265 pounds
Launch escape motor	
Length	185.3 inches
Diameter, nozzle exit	28 inches
Diameter, motor structure	26 inches
Weight	4765 pounds
Tower jettison motor	
Length	55.6 inches
Diameter, nozzle exit	28 inches
Diameter, motor structure	26 inches
Weight	534 pounds

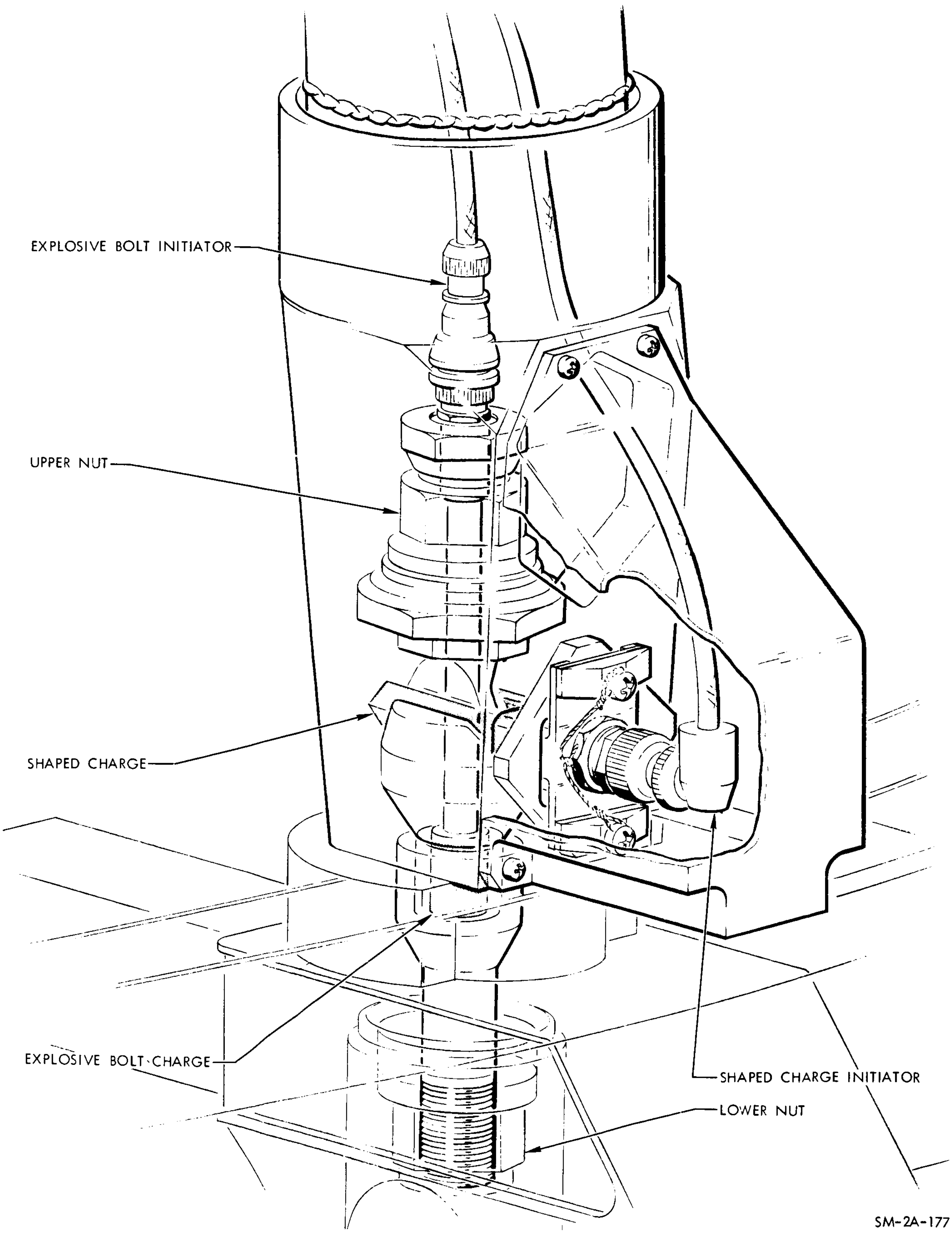


Figure 2-2. Escape Tower Explosive Bolt

Table 2-1. Launch Escape Assembly Physical Characteristics (Cont)

Major Components (Cont)	
Pitch control motor structure	
Length (includes ballast and motor structure)	18.62 inches
Diameter	26 inches
Weight	157 pounds
Pitch control motor	
Length	22 inches
Diameter, body	8.79 inches
Diameter, flange	10.51 inches
Weight	55 pounds
Ballast	
Diameters, lead discs	20.5 inches and 15.0 inches
Thickness	1.13 inches
Weight	190 pounds (approx)
Ballast enclosure	
Length	29 inches
Diameter, forward end	13.1 inches
Diameter, aft end	26 inches
Weight	67 pounds
Nose cone (Q ball)	
Length	19.09 inches
Diameter, forward end	2 inches
Diameter, aft end	13.03 inches
Weight	22 pounds

2-11. STRUCTURE. The base of the structure is an open frame of welded titanium tubing. Each of the four legs is attached to the command module by an explosive bolt. (See figure 2-2.) The structural skirt is attached between the top of the tower structure and the base of the launch escape motor. Attachments at the tower base are adjustable to facilitate tower alignment. (See figure 2-3.) The interstage structure (figure 2-4) is a welded sheet structure which houses the jettison motor exhaust nozzles and various electrical components. Two access doors facilitate installation and removal of components. The ballast housing and the nose cone are of welded inconel sheet construction and bolted together to form a single conical structure to house the sheet lead ballast and the Q-ball. (See figure 2-5.)

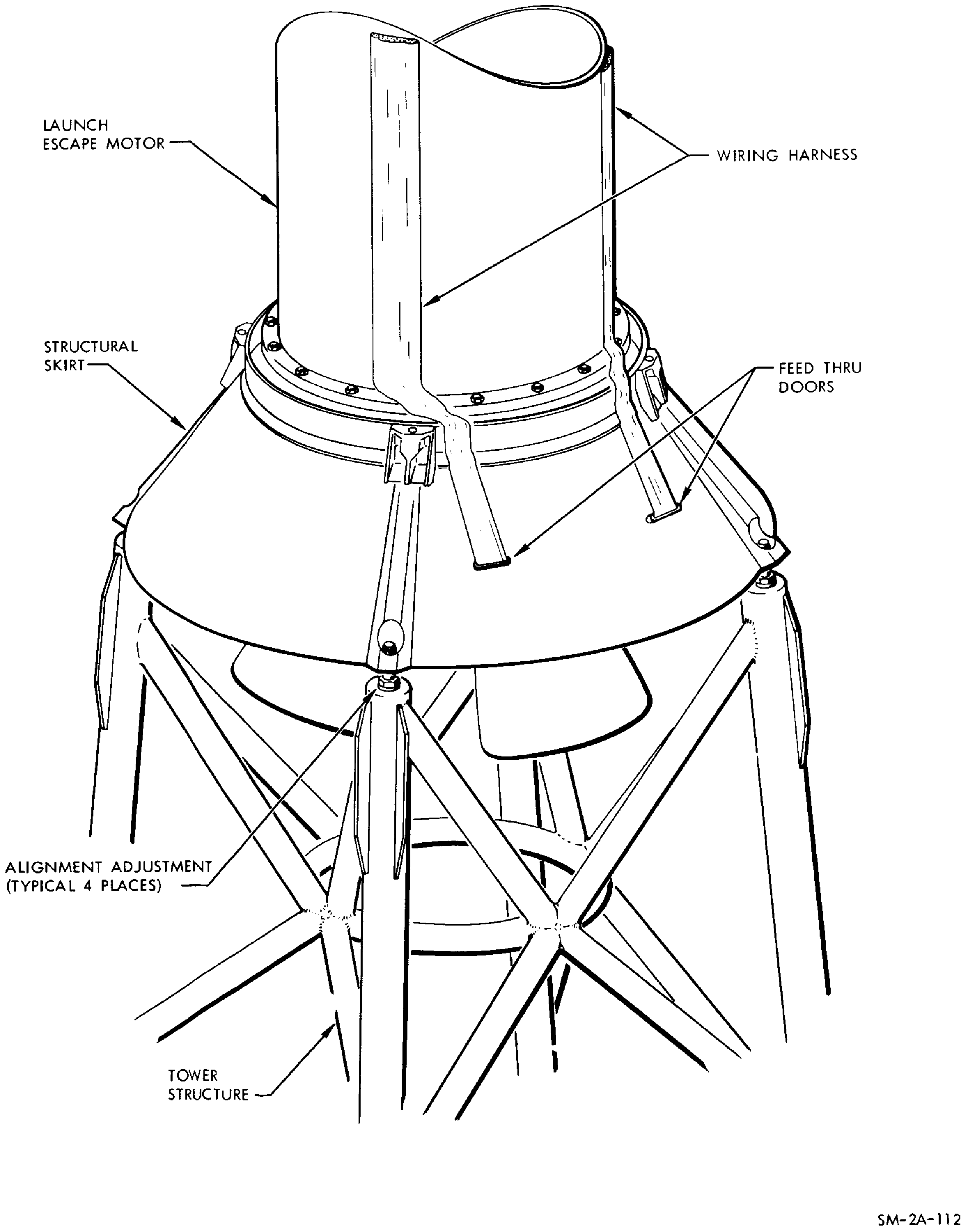


Figure 2-3. Skirt and Thrust Alignment Fitting

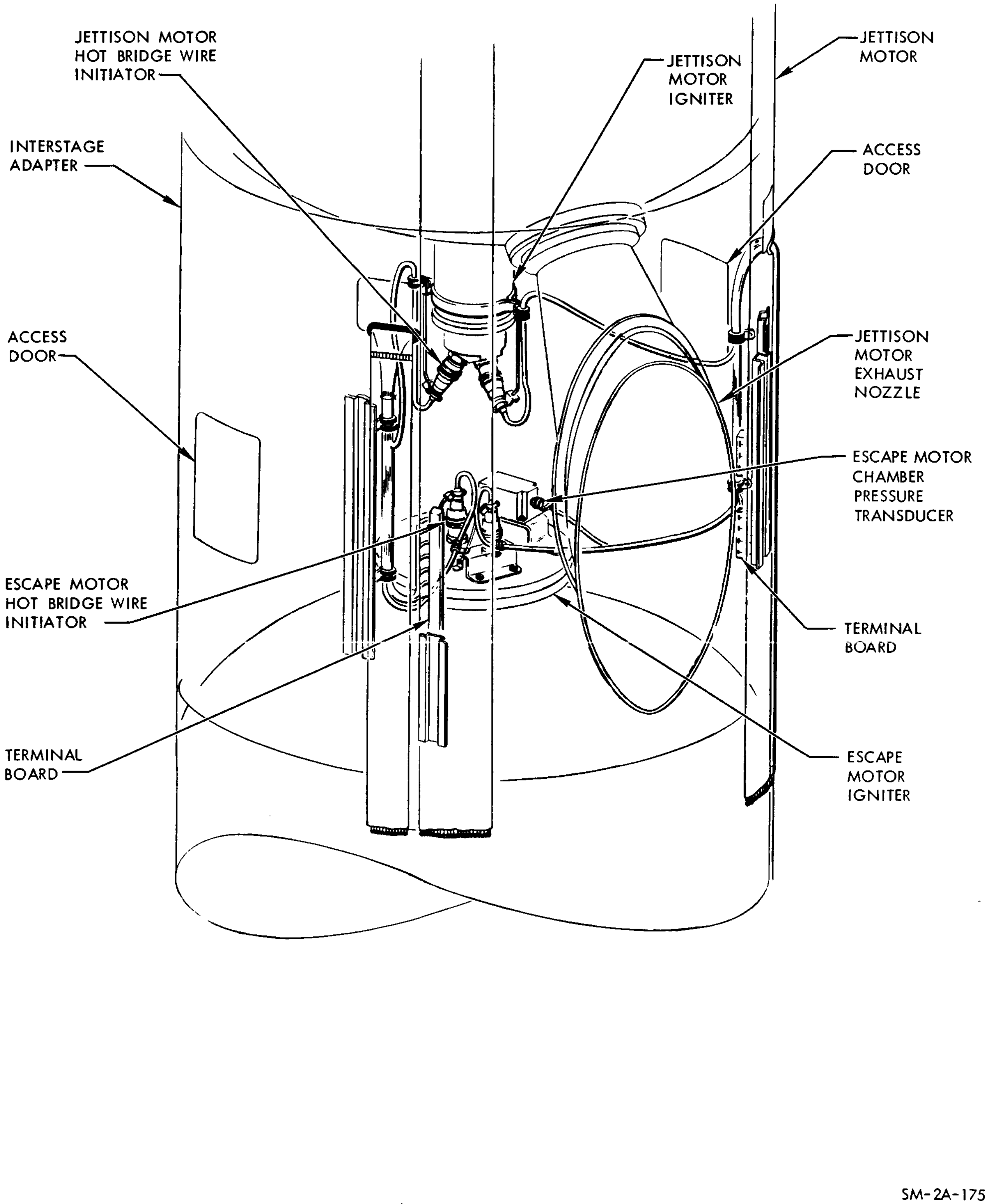


Figure 2-4. Interstage Adapter Area Components

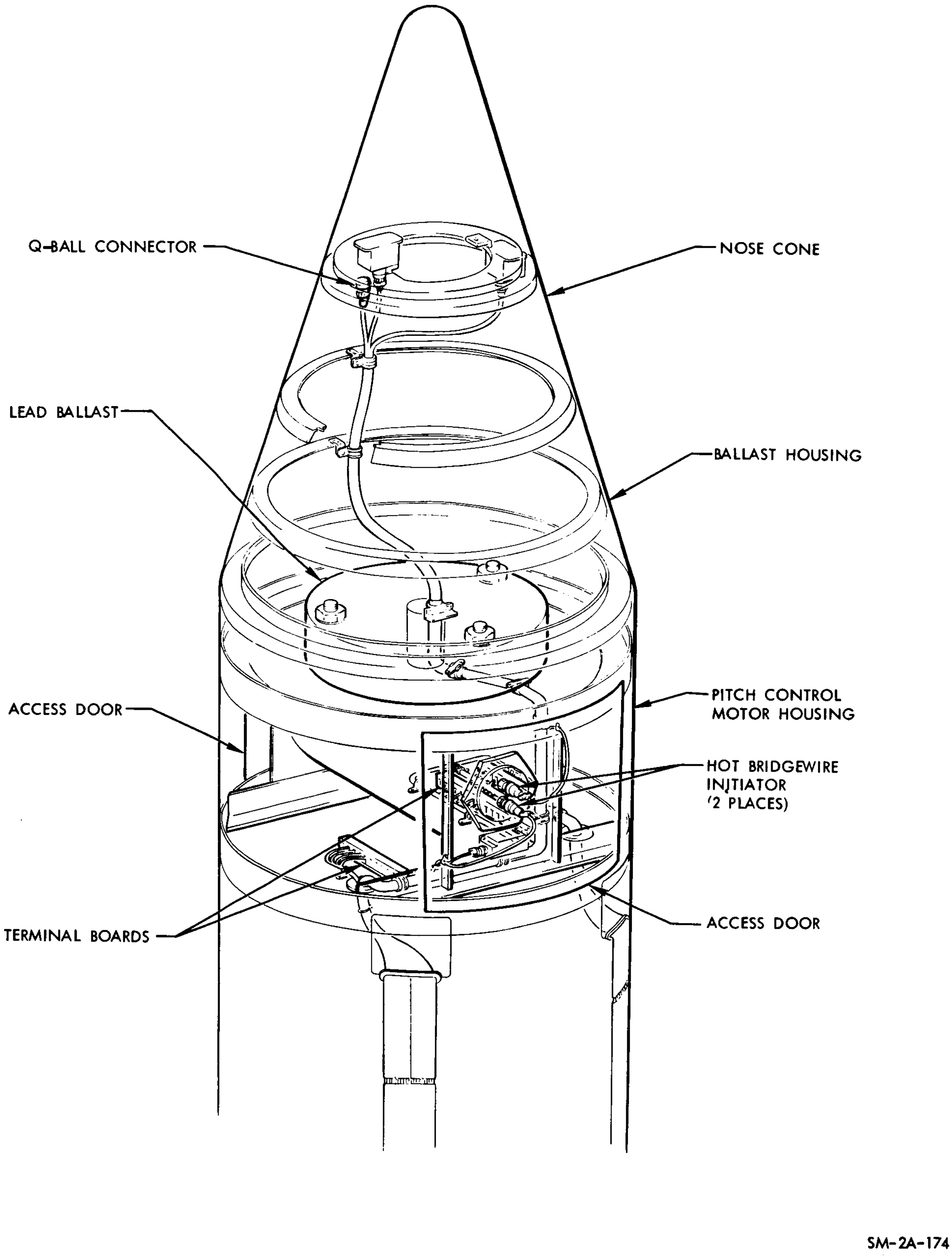


Figure 2-5. Nose Cone and Pitch Control Motor Housing

2-12. LAUNCH ESCAPE SYSTEM MOTORS. The launch escape system consists of three motors mounted above the tower structure. Each motor utilizes a star-grain solid propellant of a polysulfide ammonium perchlorate formulation. The launch escape motor has four fixed nozzles; the jettison motor, two; and the pitch control motor, a single nozzle. Passive thrust vector control is used to obtain proper escape and jettison trajectories. Alignment of the motors should be accomplished in accordance with instructions contained in SM-2A-05, Transportation and Handling Procedures.

2-13. LAUNCH ESCAPE SYSTEM ELECTRICAL AND ELECTRONIC COMPONENTS. The electrical and electronic components in the launch escape system consist of a launch escape sequencer (contained in the command module), two tower sequencers 14 HBW initiators, and associated wiring harnesses and attachments. Redundant left and right wiring harnesses are bonded to the exterior of the launch escape motor, and associated redundant harnesses are integral to the tower structure. Each tower structure harness has a breakaway plug that allows the harness to detach itself from the command module when the launch escape tower is jettisoned. The wiring harnesses provide the means of connecting the rocket motor and separation circuits with the sequence controller, and the instrumentation components with communications equipment.

2-14. TOWER SEQUENCERS. Two tower sequencers are located under the tower structural skirt assembly. They are mounted vertically on brackets adjacent to the tower legs through which the wiring harnesses are routed. The sequencer boxes are approximately 9 inches long, 5 inches high and 4-1/2 inches wide.

2-15. LAUNCH ESCAPE SEQUENCER. The launch escape sequencer is a part of the launch escape system, but it is installed in the command module; it is a single enclosed assembly approximately 23 inches long, 8 inches high, and 7 inches wide; refer to section III for an operational description.

2-16. LAUNCH ESCAPE TOWER UMBILICAL CONNECTORS. Two electrical connectors join the electrical systems of the launch escape assembly and the command module. These connectors are located on the plane of separation in adjacent escape tower leg wells of the forward heat shield of the command module. (See figure 2-2.) The receptacle portion of the connector is attached to the command module structure; the plug is attached to the escape tower leg nearest to it by a lanyard. When the escape tower separates from the command module, the lanyard pulls the plug from the receptacle. The plugs are part of the launch escape tower wiring installation and separate with the tower. The receptacles are part of the command module wiring installation and remain with the command module.

2-17. COMMAND MODULE. (See figures 2-6 and 2-7.)

2-18. The boilerplate command module simulates the production command module in external size and shape and in structural soundness, mass, and center of gravity.

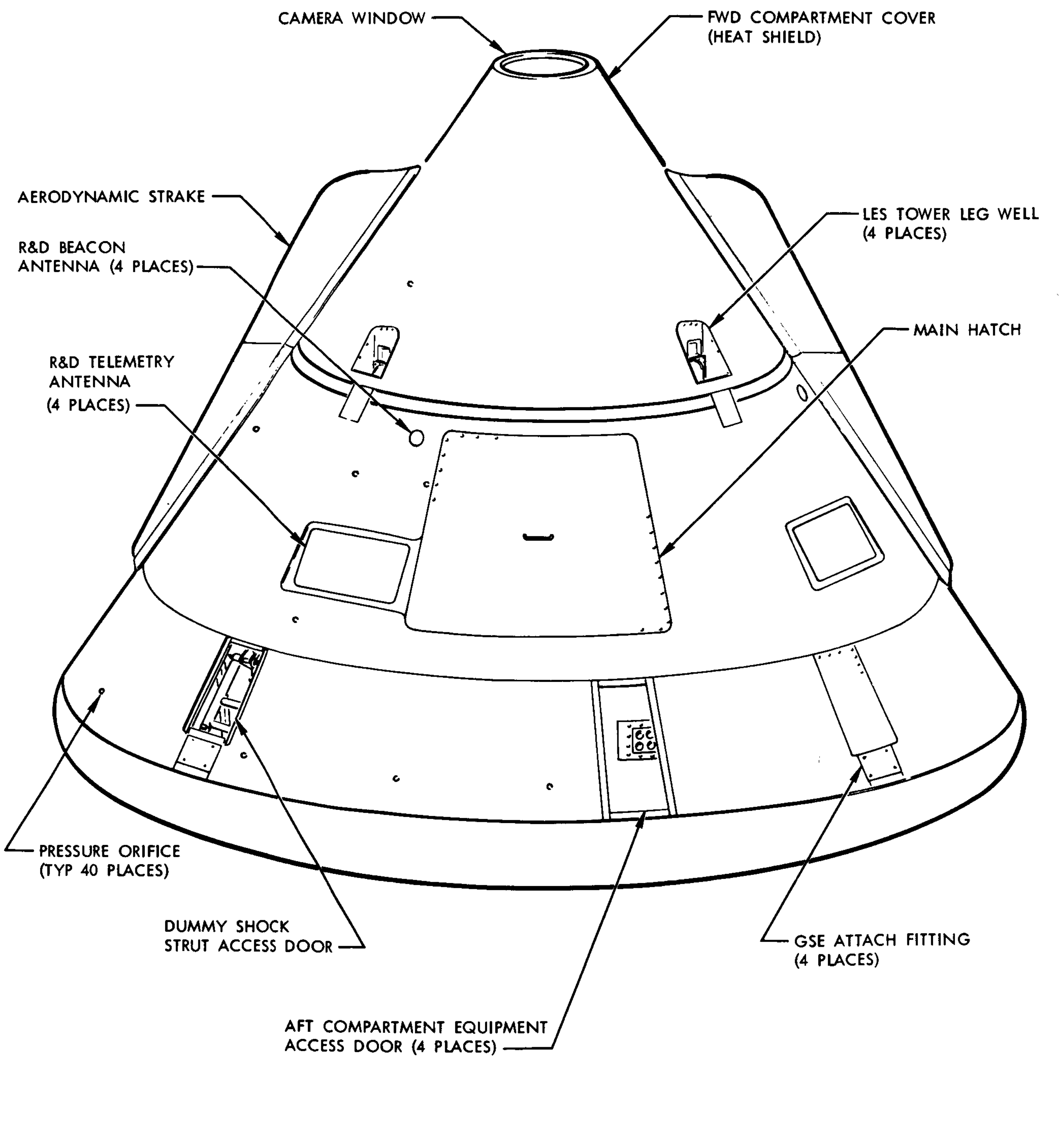
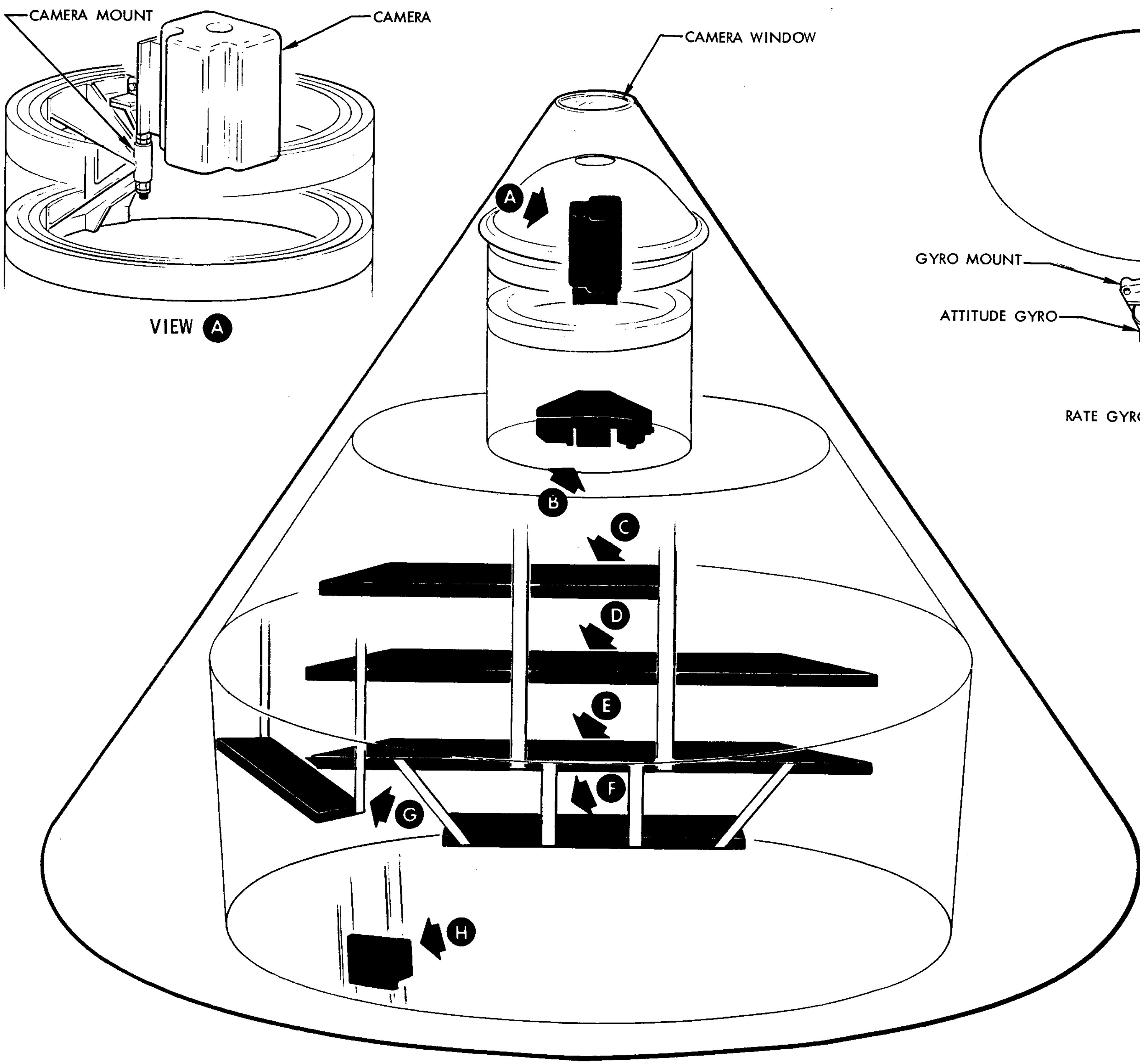
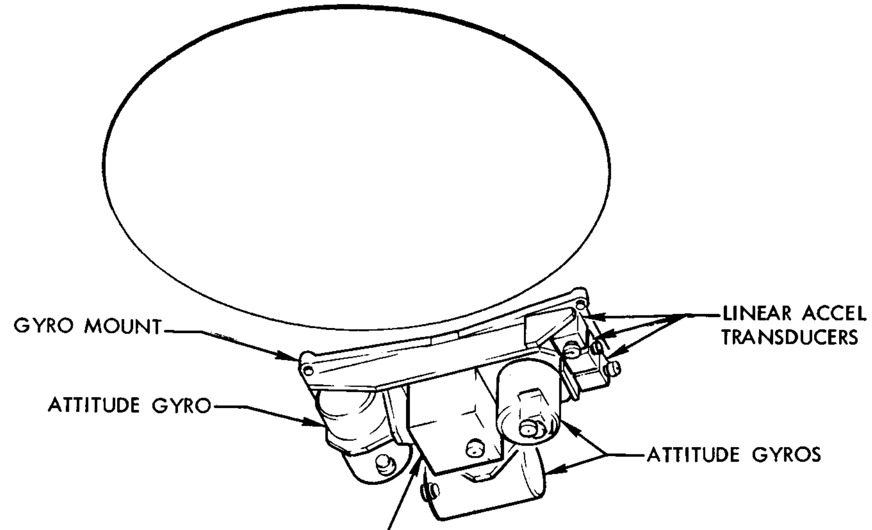


Figure 2-6. Command Module Exterior





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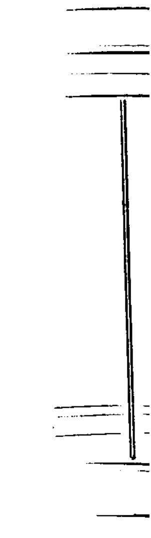

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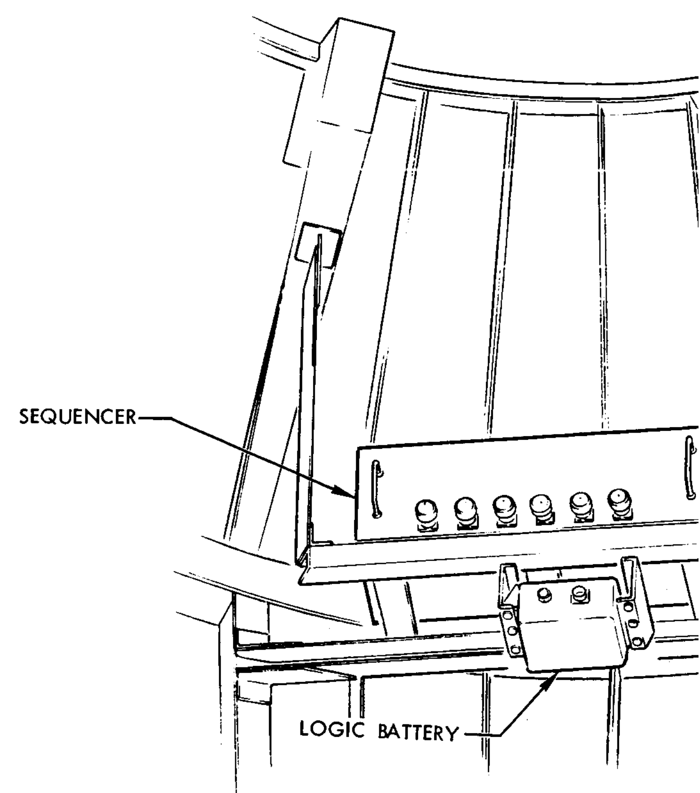

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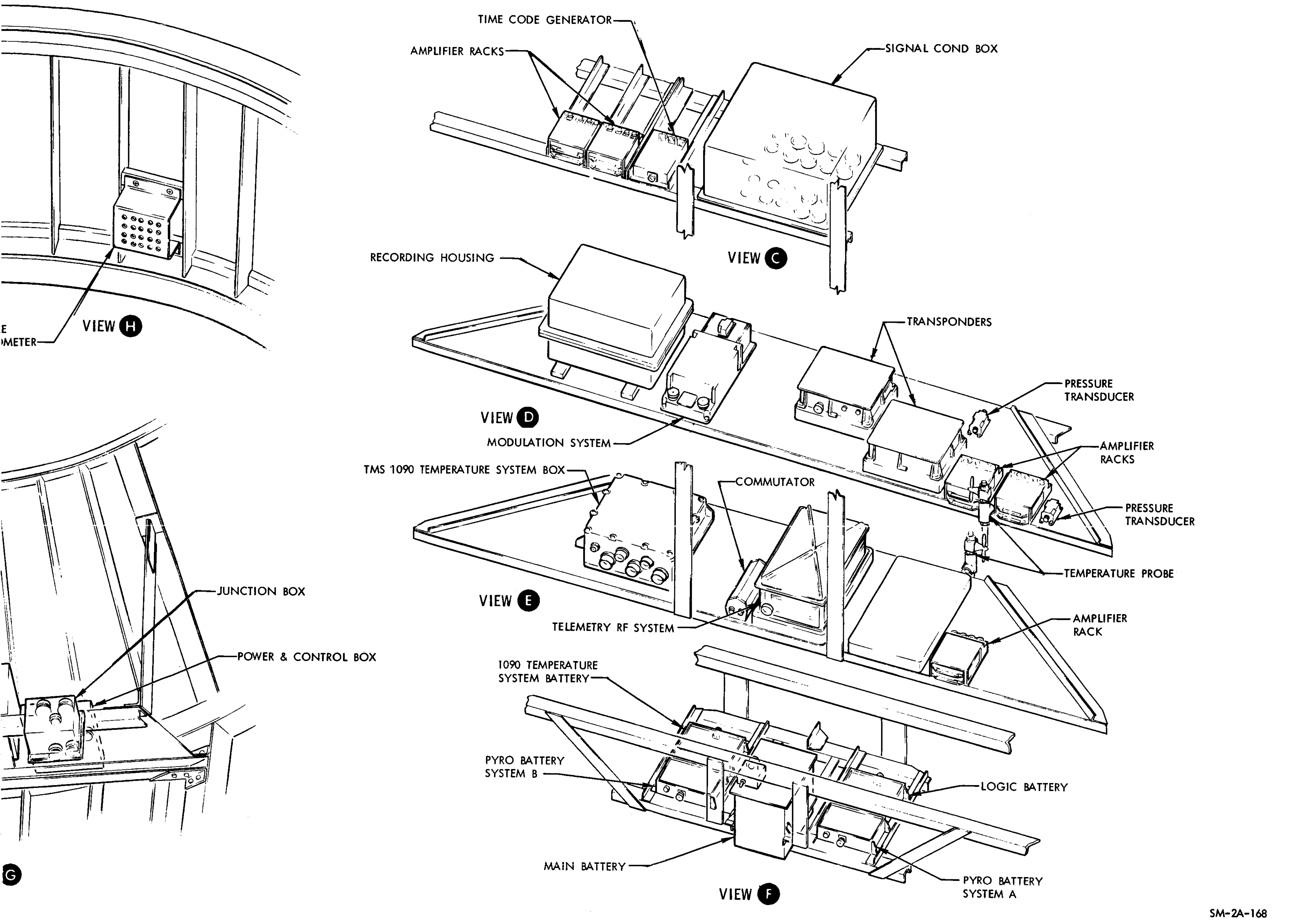


2

Figure 2-7. Command Module Interior

Physical characteristics for the command module are listed in table 2-2. The reference axes are shown in figure 2-8.

Table 2-2. Command Module Physical Characteristics

Shape	Conical
Height (overall)	134 inches
Diameter (overall)	154 inches
Weight (nominal)	9000 pounds
Aerodynamic Stabilization	2 strakes (fins) located on XY plane

2-19. **STRUCTURE.** The command module is conical is shape, with a convex base and a rounded apex. It consists of an aluminum alloy primary structure with forward and aft heat shields. A main hatch in the side of the primary structure permits access to the interior. Shelves and brackets along the inner wall afford mounting provisions for equipment. Compartmentation is described in table 2-3.

Table 2-3. Command Module Compartmentation

Compartment	Production Configuration Function	Boilerplate 12 Contents
Primary Structure	Crew Compartment	LES Sequencer R & D communication R & D instrumentation Ballast to simulate weight and center of gravity Egress tube to simulate production tube volume Main hatch
Forward Compartment	Houses parachute systems of ELS, reaction thrust jets, and associated equipment	Earth landing system Apex (forward) heat shield Heat shield separation mechanism

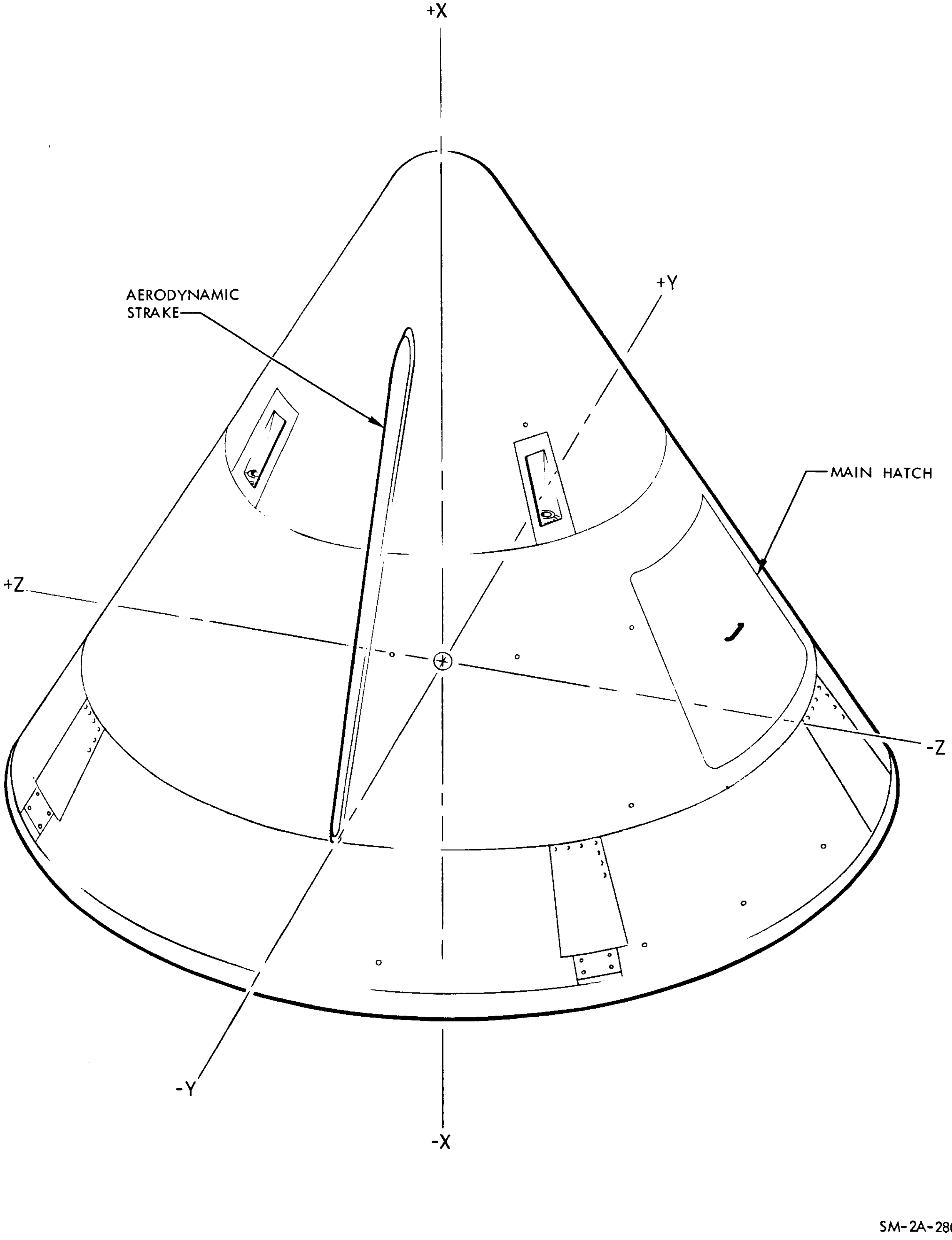


Figure 2-8. Command Module Reference Axes

Table 2-3. Command Module Compartmentation (Cont)

Compartment	Production Configuration Function	Boilerplate 12 Contents
Aft Compartment	Houses impact attenuation struts and environmental control and reaction control systems storage facilities	Aft heat shield attachment fittings GSE attachment fittings Umbilical connectors Pressure transducers Equipment access doors Service module mating bearing pads and tension ties

2-20. **FORWARD HEAT SHIELD. The forward heat shield forms the apex of the command module and provides a protective cover for the earth landing parachute subsystem. It is constructed of aluminum alloy with an inner and outer skin. The smooth surface of the inner skin precludes tearing or cutting of the parachute fabrics. The dome of the heat shield has been removed and a flat, 9-inch camera window installed. The heat shield is attached to the primary structure by two** tension tie bolts. The tie bolts are parted and the forward heat shield is separated from the primary structure prior to parachute deployment by the heat shield separation system.

2-21. AFT HEAT SHIELD. The aft heat shield forms the convex base of the command module. It is constructed of aluminum honeycomb bonded to the inner and outer skins of laminated fiberglass and attached to the primary structure by six dummy shock struts. (See figure 2-9.) Two umbilical electrical connectors are installed in the shield for connection to the service module. Six holes cut through the shield allow the command module bearing points to protrude, and three holes cut through the shield permit the command module-to-service module tension tie bolts to be installed for service module attachment.

2-22. EARTH LANDING SYSTEM EQUIPMENT. (See figure 2-10.) The ELS equipment is located in the forward compartment. Refer to table 2-4 for a list of major components and physical characteristics.

2-23. Drogue Parachute Subsystem. This subsystem consists of a drogue parachute deployment bag, a mortar assembly, a riser, a disconnect assembly, and a pair of pyrotechnic cartridges.

2-24. Pilot Parachute Subsystem. The three pilot parachute subsystems consist of pilot parachutes, deployment bags, mortar assemblies, risers, and pyrotechnic cartridges. Each pilot parachute serves to deploy one of the three main parachutes.

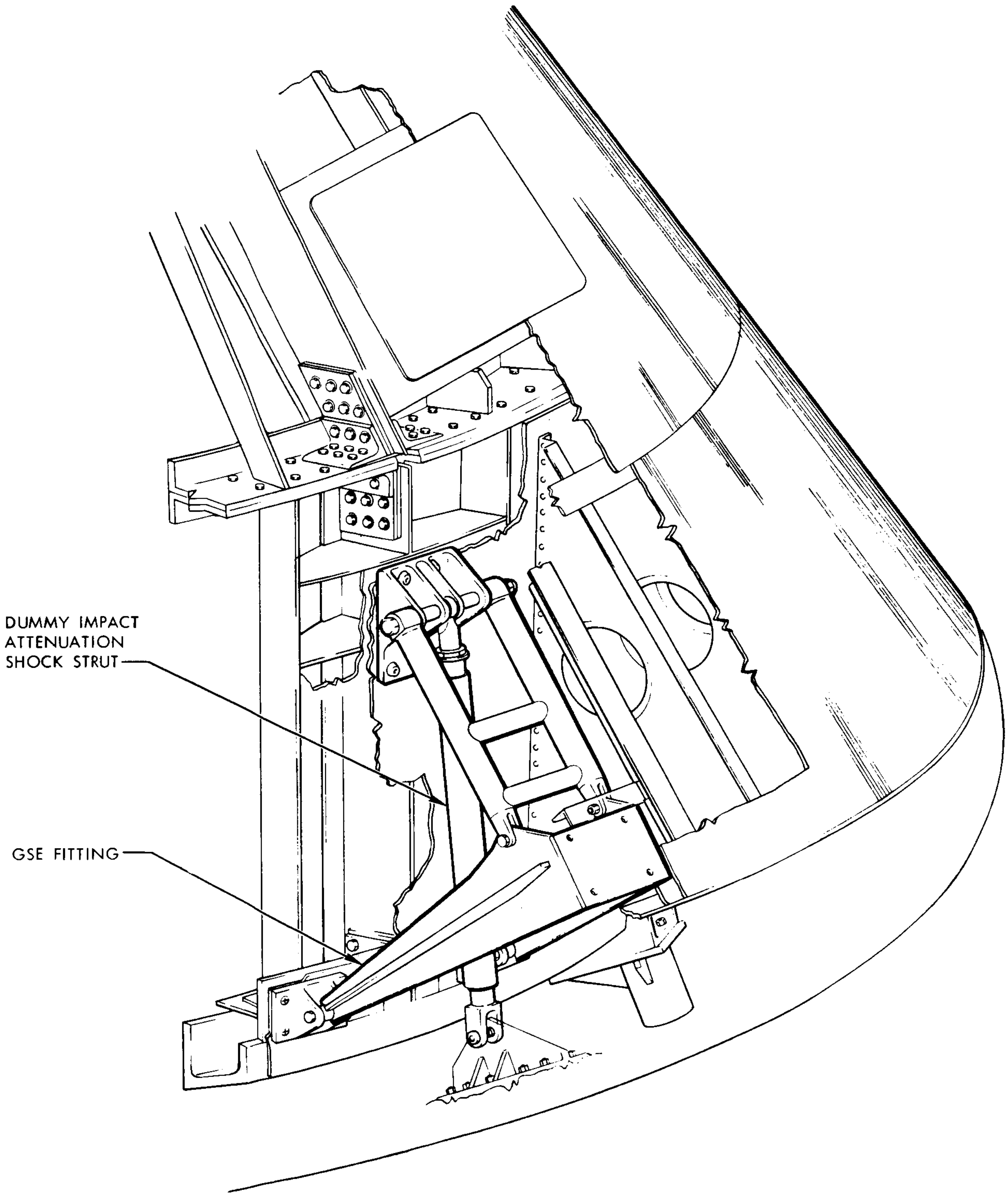


Figure 2-9. Dummy Shock Strut and GSE Attach Fitting

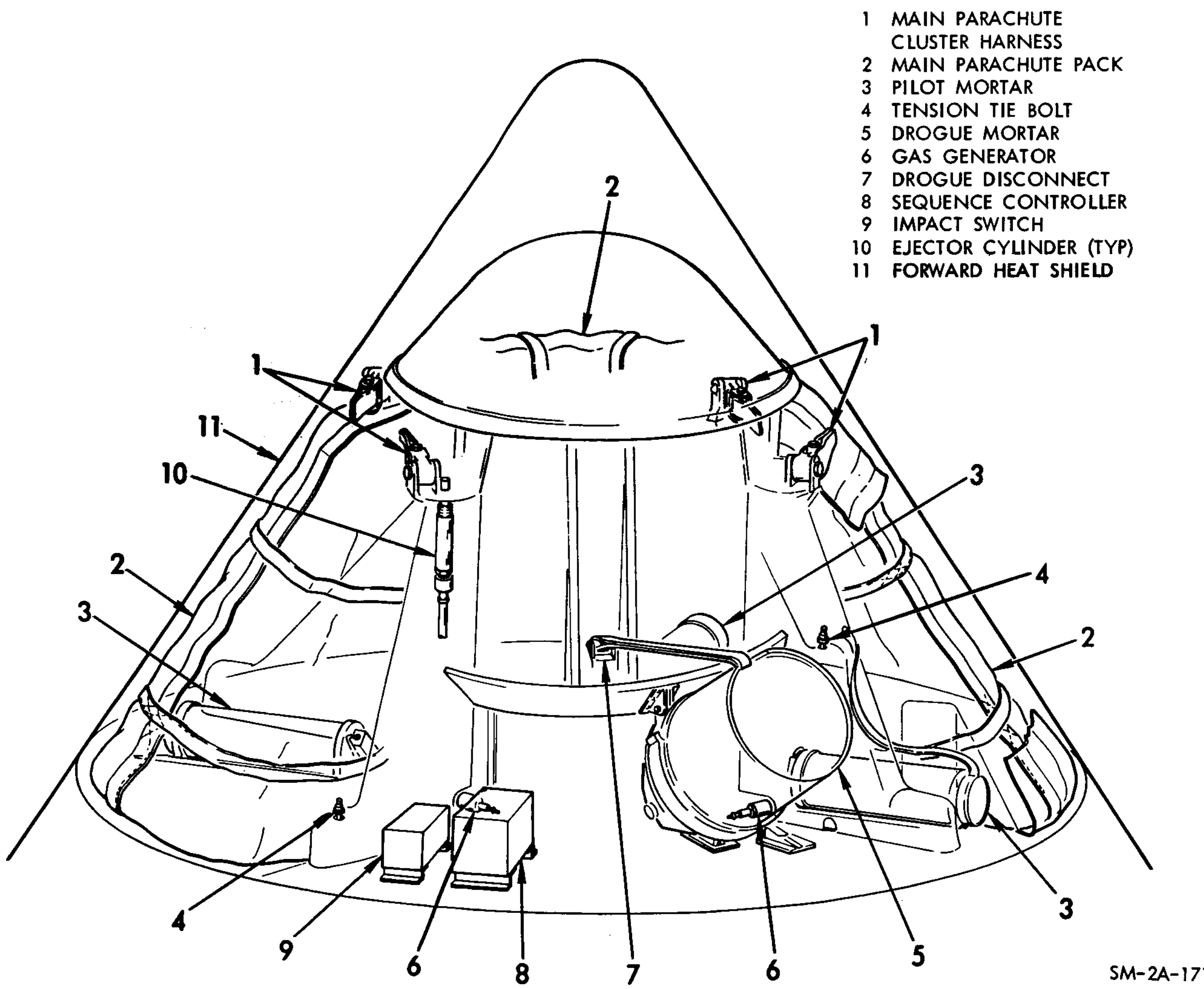


Figure 2-10. Earth Landing System

Table 2-4. ELS Major Components and Physical Characteristics

Main Parachutes (3 required)	
Type	Ring-sail
Diameter (deployed)	88.1 feet
Weight	121 pounds
Method of deployment	Pilot parachute
Drogue Parachute (1 required)	
Type	Conical ribbon
Diameter (deployed)	13.7 feet
Weight	25.2 pounds
Method of deployment	Mortar
Pilot Parachute (3 required)	
Type	Ring-slot
Diameter (deployed)	10.0 feet
Weight	5.0 pounds
Method of deployment	Mortar
Drogue Mortar (1 required)	
Firing current	3.5 amperes
Firing voltage	28 volts
Length	14.75 inches
Diameter	11.50 inches
Weight	11.0 pounds
Pilot Mortar (3 required)	
Firing current	3.5 amperes
Firing voltage	28 volts
Length	15.53 inches
Diameter	4.78 inches
Weight	4.5 pounds
Forward Heat Shield	
Height	51.1 inches
Diameter	76.1 inches
Weight	246 pounds
Ejector Cylinder (4 required)	
Inside diameter	1.243 inches

Table 2-4. ELS Major Components and Physical Characteristics (Cont)

Sequence Controller		
	Length	9.13 inches
	Width	6.36 inches
	Height	8.00 inches
	Weight	13.52 pounds

2-25. Main Parachute Pack Assemblies. Each of the main parachute pack assemblies consists of a main parachute, deployment bag, riser, and pack retention flaps.

2-26. Main Cluster Disconnect and Harness Assembly. Each of the main parachute risers is attached to one end of the main parachute cluster disconnect. The disconnect assembly is attached to the harness assembly which is in turn connected to fittings on the command module structure.

2-27. Sequence Controller. The controller is an electrical assembly containing timers and relays which sequence events during the descent of the command module. Refer to section IV for an operational description of the sequence controller.

2-28. FORWARD HEAT SHIELD RELEASE SYSTEM. (See figure 2-10.) The forward heat shield release system consists of a pair of pyrotechnic cartridges, two gas generators, and four ejector cylinders and rods. The rods are connected to the forward heat shield and transmit the force necessary to accomplish release by parting the tension tie bolts which attach the forward heat shield to the command module primary structure. The ejector cylinders are mounted along the upper outside rim of the air lock structure. The gas generators are mounted on the upper surface of the forward bulkhead and connected to the ejector cylinders by tubing.

2-29. R & D INSTRUMENTATION EQUIPMENT. Boilerplate 12 instrumentation subsystems consist of R & D communications and instrumentation and R & D power and control. The communications and instrumentation equipment is divided into six functional groups: transducers, signal conditioning, telemetry, RF transmission, timing, and recording. For a complete list of R & D instrumentation equipment contained in boilerplate 12, refer to table 2-5.

2-30. ANTENNA SYSTEMS. (See figures 2-6 and 2-7.) There are two antenna systems furnished by NAA in boilerplate 12: an R & D telemetry system and an R & D beacon system.

2-31. R & D Telemetry Antenna System. This system consists of four H-shaped slot antennas mounted flush with the exterior skin of the command module and spaced 90 degrees apart. One is mounted adjacent to the lower left corner of the

Table 2-5. R & D Instrumentation Equipment

Equipment	Supplier	Quantity
Acceleration Transducer	NASA*	6
Amplifier	NASA*	13
Amplifier Rack	NASA*	10
Antenna	NAA	8
Attitude Gyroscope	NASA*	3
Battery	NASA*	8
Camera	NASA*	5
Control Box	NASA*	1
Junction Box	NASA*	1
Pressure System	NASA*	12
Pressure Transducer	NASA*	42
Signal Condition Box	NASA*	1
Tape Recorder	NASA*	1
Telemetry Package	NASA*	2
Temperature System	NASA*	1
Timer (coded)	NASA*	1
Transponder (C-band)	NASA*	2
Rate Gyroscope Package	NASA*	1
Q Ball	NAA	1

* Refer to applicable NASA description, checkout, and familiarization manuals for NASA supplied equipment.

main hatch. Transmission is on two frequencies between 225 and 260 megacycles with a total power of 10 watts when operated in conjunction with the boilerplate 12 power amplifier.

2-32. R& D Beacon Antenna System. This system consists of four disc-shaped antennas approximately four inches in diameter mounted flush with the exterior skin of the command module and spaced approximately 90 degrees apart; one is mounted adjacent to the upper left corner of the main hatch. This antenna system will transmit at a nominal frequency of 5500 megacycles at an average power of one watt in conjunction with two C-band transponders.

2-33. SERVICE MODULE. (See figure 1-1.)

2-34. The simulated service module is used primarily to transmit thrust loads from the launch vehicle to the spacecraft. The command module rests on the service module at six compression bearing points. Three tension ties hold the command module mating bearing points firmly nested until a pyrotechnic charge cuts the ties at time of launch escape initiation. The service module is bolted to a structure extension which is in turn bolted to the spacecraft booster. The service module remains with the booster after command module separation. A mount is installed near the bottom of the service module to support a camera which observes command module separation.

2-35. STRUCTURE. The cylindrical outer shell of the simulated service module is approximately 12 feet long and 13 feet wide and is constructed of welded steel sheet riveted to sheet steel circular frames. The six bearing bolts attached to the primary structure which transmit thrust loads are adjustable to facilitate command module to service module alignment.

2-36. STRUCTURE EXTENSION. The structure extension is cylindrical in shape and is approximately 10 inches long and 13 feet in diameter; it is constructed of sheet steel that is riveted to upper and lower frames. The upper frame is composed of steel angles and webs riveted together. The lower frame is constructed of rectangular steel tubing. A concave, laminated fiberglass bulkhead is attached to the lower frame. The structure extension is bolted to the Little Joe II spacecraft booster.

2-37. SERVICE MODULE TENSION TIE BOLTS. (See figure 2-11.) These bolts are steel turnbuckle assemblies approximately 42 inches long. Two of the assemblies installed at longerons No. 4 and No. 6 use 7/8-inch hexagon steel rods 28.5 inches long. The third tie at longeron No. 2 uses a 1-1/4-inch round steel rod 28.6 inches long on which hexagonal wrench flats have been machined. On each tie bolt, a flat strap section 0.17 inch thick, 2.75 inches wide, and 2.50 inches long is provided for installation of two pyrotechnic cutting charges. These charges sever the tie bolts during command module-to-service module separation. One rod end mates a fitting on the command module, and the other mates a fitting on the service module. The tension tie bolts are utilized to preload the command module-to-service module compression bearing points.

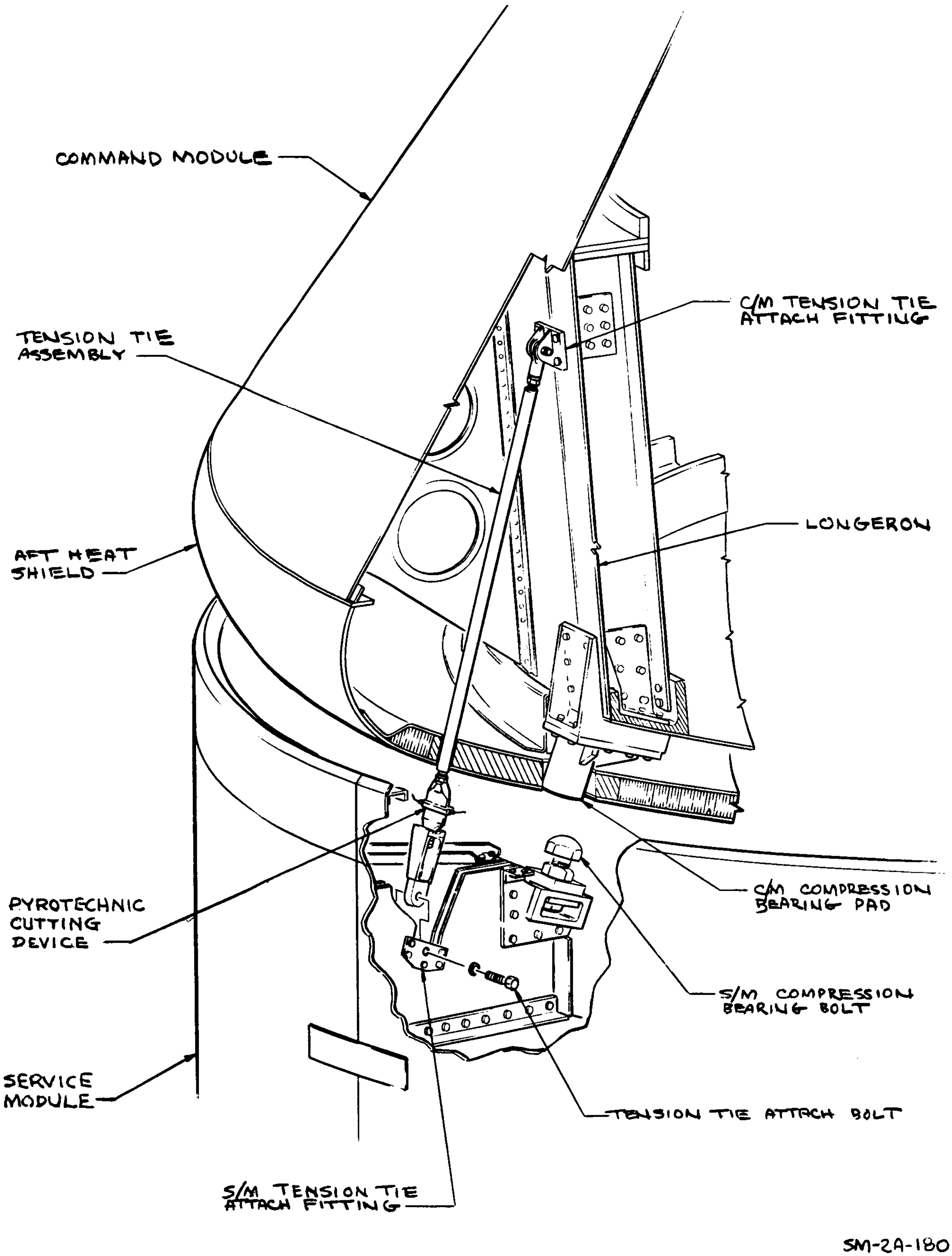


Figure 2-11. Service Module Tension Tie

2-38. UMBILICAL CONNECTORS. (See figure 2-12.) The umbilical connectors on boilerplate 12 consist of electrical connectors located on the planes of separation of the modules. These connectors join the electrical systems of the modules together while the modules are attached and provide the means of disconnecting the electrical systems upon module separation. The service module contains five umbilical connectors.

2-39. Command Module Umbilical Connectors. Two umbilical connector receptacles are recessed into the outer surface of the aft heat shield of the command module. They are approximately 12 inches from the outer edge and located on either side of longeron No. 6. The receptacles are part of the command module aft compartment wiring installation. The plug portions of the connectors are part of the service module wiring installation; they are attached to lanyards fastened to the service module structure. When the command module separates from the service module, the lanyards strip the plugs from the receptacles and retain them with the service module.

2-40. GSE Umbilical Connector. A receptacle for attaching a GSE umbilical cable is located in the skin of the service module approximately 18 inches below the top on the positive Z plane. The mating plug which is attached to the GSE electrical cabling is equipped with a lanyard which, when pulled, will release the plug from the receptacle and remove it from the service module.

2-41. Little Joe II Umbilical Connectors. Two electrical umbilical receptacles are mounted in a bracket near longeron No. 3 of the service module. The bracket is attached to the inner surface of the lower frame of the structure extension at the base of the service module. These receptacles mate plugs on the Little Joe II booster to connect the electrical systems of the spacecraft to the electrical system of the booster. Boilerplate 12 service module is bolted to the booster and does not separate from it during the flight.

2-42. LAUNCH VEHICLE. (See figure 1-1.)

2-43. The launch vehicle is a Little Joe II spacecraft booster which is mounted on a launch platform on the launch pad for elevation and azimuth orientation. Four fins stabilize the cylindrical airframe. The airframe is approximately 13 feet in diameter and 29 feet in length. The fins sweep back from the aft body and are approximately 28 feet from tip to tip. The power configuration for the high dynamic pressure abort launch provides 310,000 pounds of initial thrust, which reduces to approximately 103,000 pounds of thrust sustained for 36 seconds. An adapter, called the structure extension, bolts to the service module and to the Little Joe II airframe.

2-44. OPERATIONAL DESCRIPTION.

2-45. The R & D systems incorporated in boilerplate 12 consist of an R & D communications and instrumentation system, an R & D power and control system, and

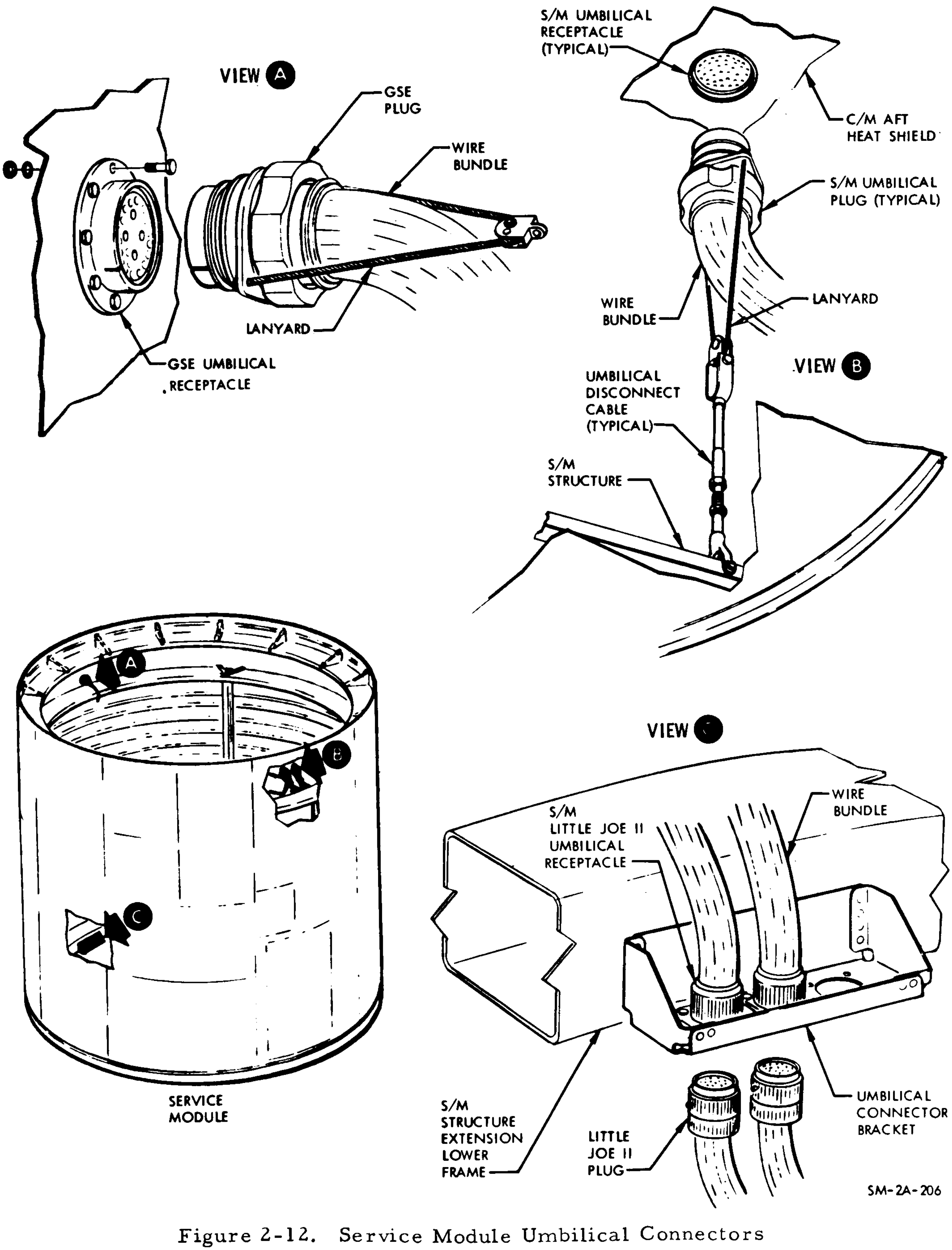


Figure 2-12. Service Module Umbilical Connectors

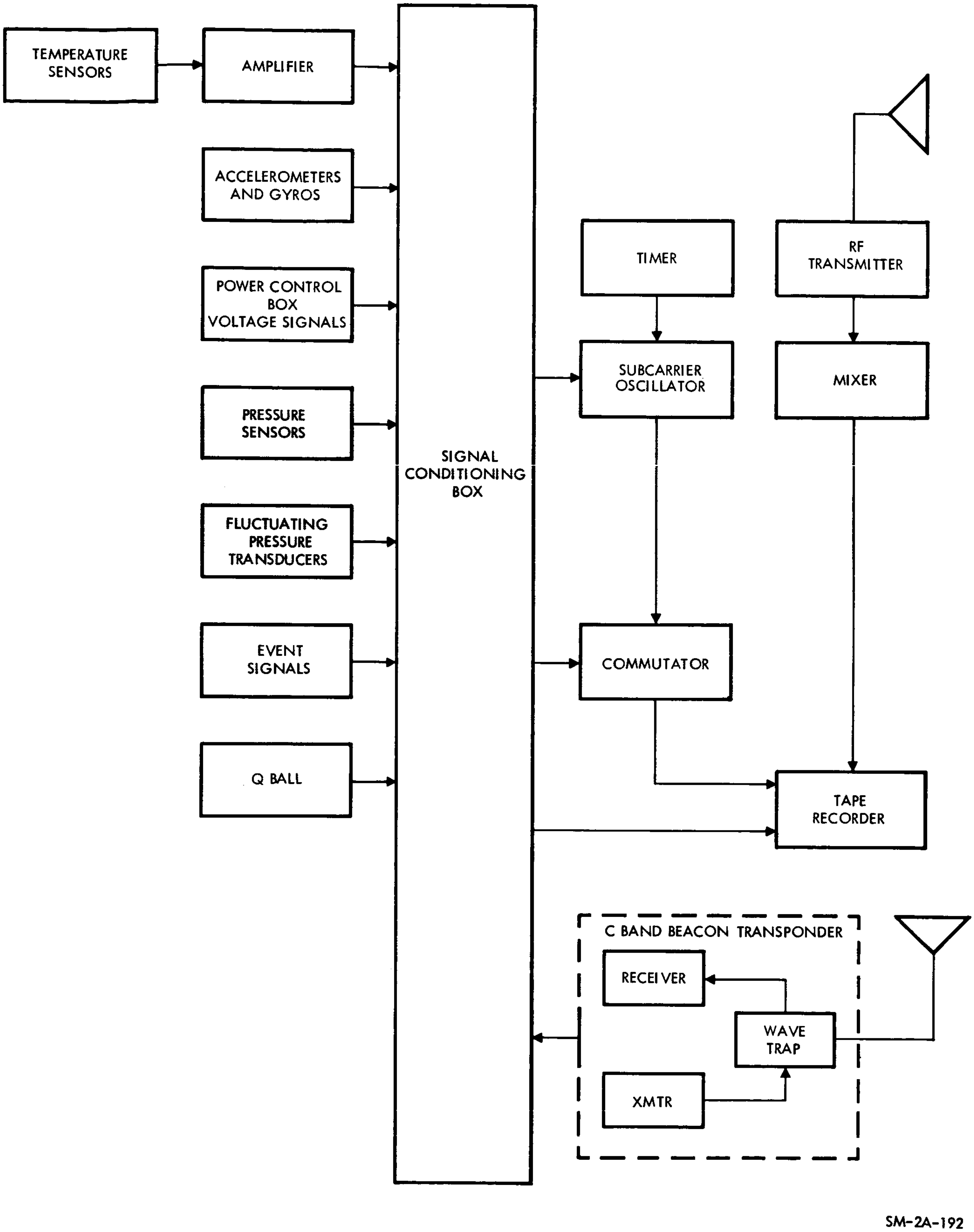


Figure 2-13. Communication and Instrumentation System Block Diagram

an attitude and dynamic pressure (Q-ball) system. The launch escape system and the earth landing system are described in sections III and IV.

2-46. R & D COMMUNICATIONS AND INSTRUMENTATION. (See figures 2-13 and 2-14.)

2-47. This R & D system provides a means of acquiring and storing data pertinent to the mission. Acquisition and storage is accomplished by means of transducers, on-board recorders, cameras, and RF telemetry transmission. Specific data acquired consists of acceleration, attitude, and angular rate in each of the roll, yaw, and pitch planes; conical surface and base pressure measurements, launch escape motor and pitch control motor chamber pressure measurements; command module interior temperature, and temperature measurements in the telemetry equipment, transmitter, and RF power amplifier. Cameras observe LES motor fire, motor plume patterns, tower separation, command module separation, forward heat shield separation, and parachute deployment.

2-48. NASA FURNISHED EQUIPMENT. For descriptive and checkout information for the R & D electronic equipment furnished by NASA, refer to applicable NASA description, familiarization, and checkout manuals.

2-49. Q-BALL. (See figures 2-15 and 2-16.) Three pressure transducers with associated attachment and electronic wiring form the NAA furnished Q-ball system. Data acquired by the Q-ball includes angle of attack, angle of sideslip, and dynamic ram pressures. The transducers are located in the LES nose cone and sense airflow direction and pressure through ports in the nose cone surface. The input is 28 volts dc. The transducers are capacitive-balanced with conversion of input power to 8 kilocycles. The output of the transducers is proportional to the three differential pressures measured. The transducer outputs are applied to the telemetry equipment after amplification and conversion to direct current.

2-50. R & D POWER AND CONTROL. (See figures 2-7, 2-17, and 2-18.)

2-51. Electrical power for boilerplate 12 systems and equipment is provided by nine multi-cell, 28-volt, zinc-silver oxide batteries. Four of these batteries supply the system sequencer, three supply the cameras and the remaining two supply the spacecraft equipment in the command and service modules.

2-52. Four 18-cell, 6-ampere-hour batteries provide power to the A and B logic and pyrotechnic buses in the earth landing system sequencer. These same batteries provide power to both the A and B logic and pyrotechnic buses in the launch escape sequencer. Each of the three R & D instrumentation cameras is supplied by an 18-cell 6-ampere-hour battery mounted adjacent to the camera. There are cameras mounted on the launch escape tower and in the interior of both the command and service modules.

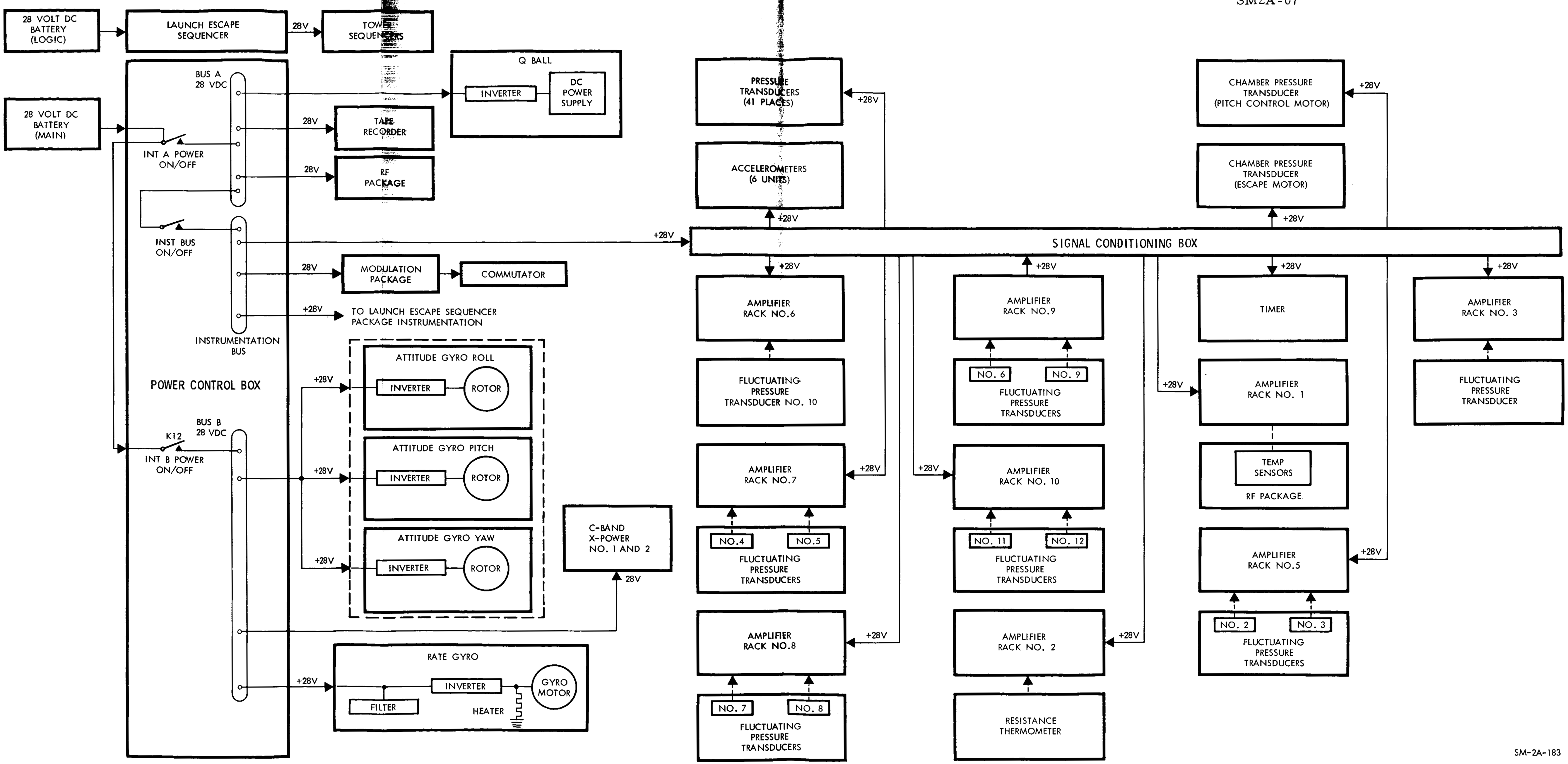


Figure 2-14. Sensing and Timing Devices, 28-Volt D-C Supply Block Diagram

2-53. The main battery which is located in the command module provides power to the communications, instrumentation, and miscellaneous equipment. An additional battery provides power to the TMS-1090 micro-dot temperature measuring system.

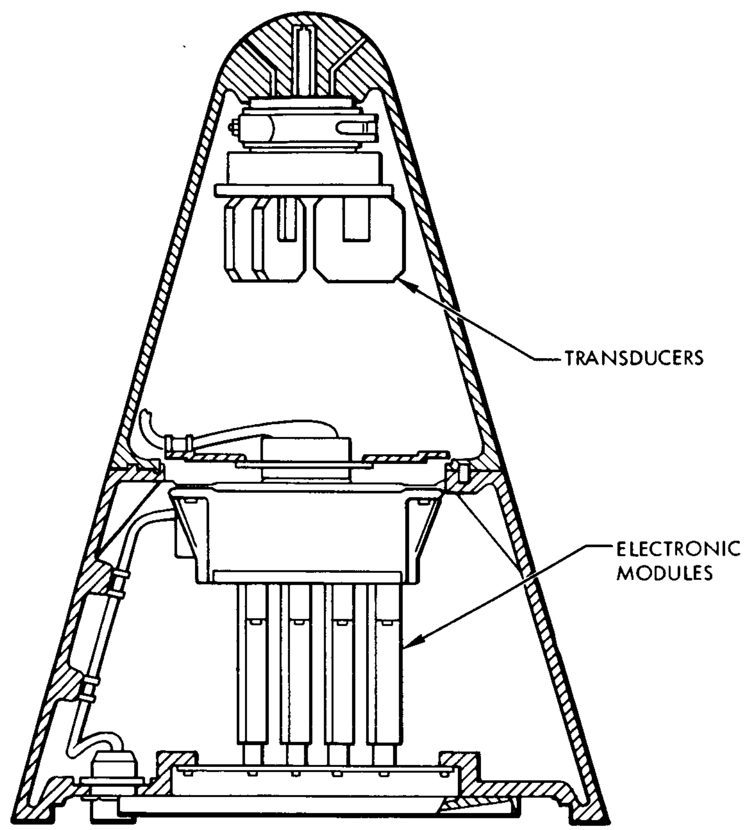


Figure 2-15. Nose Cone Interior

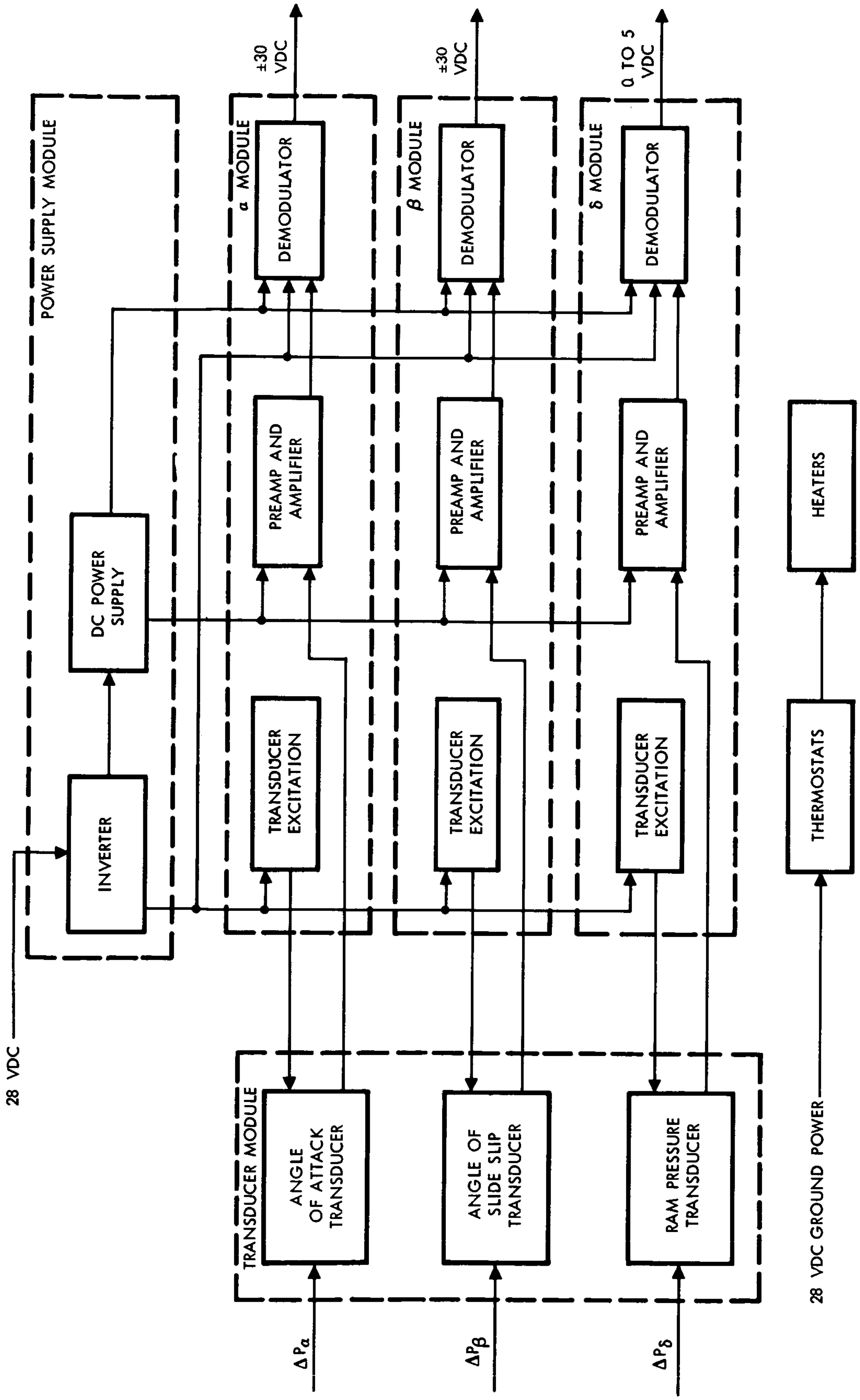


Figure 2-16. Q-Ball Block Diagram

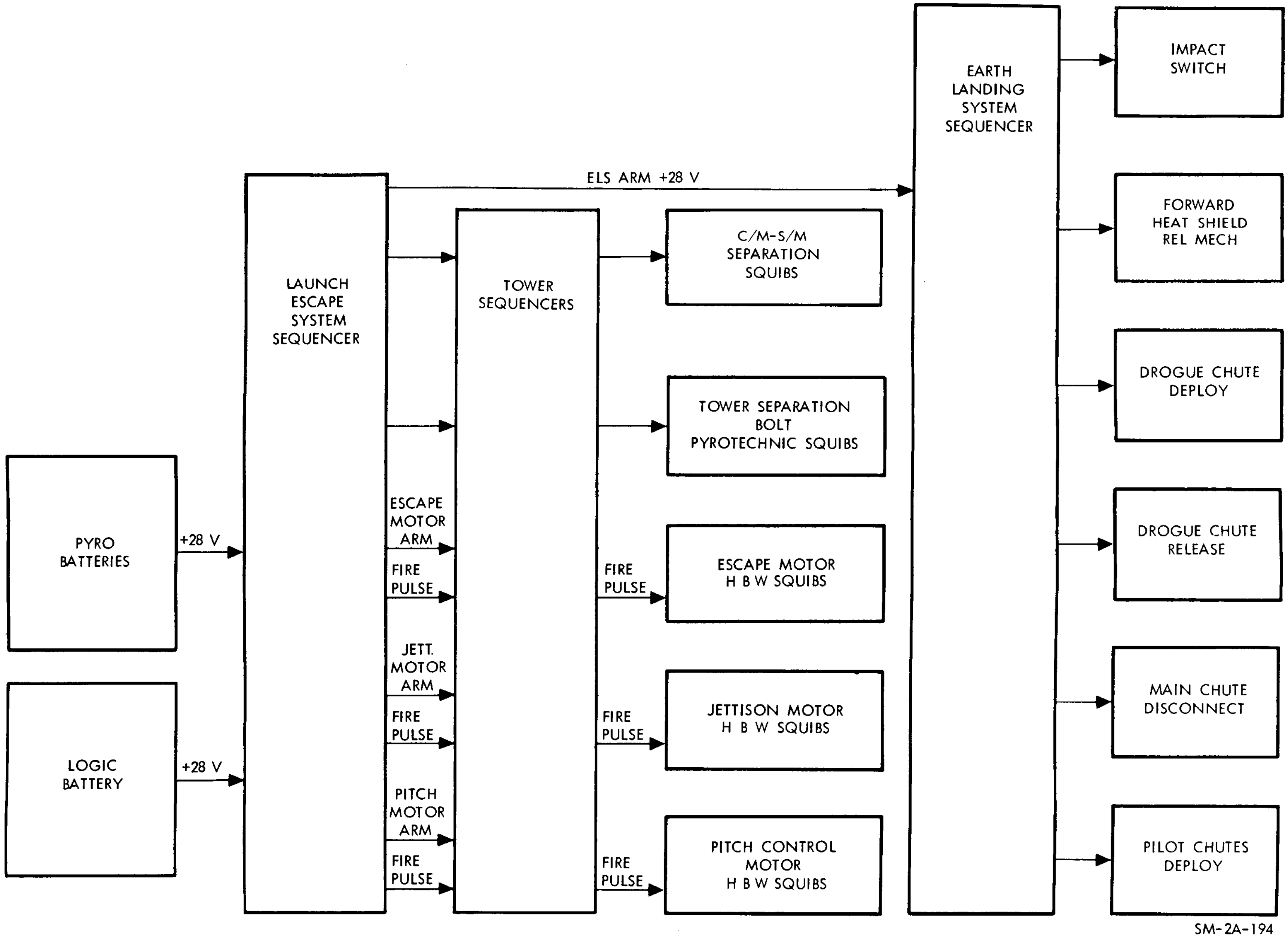
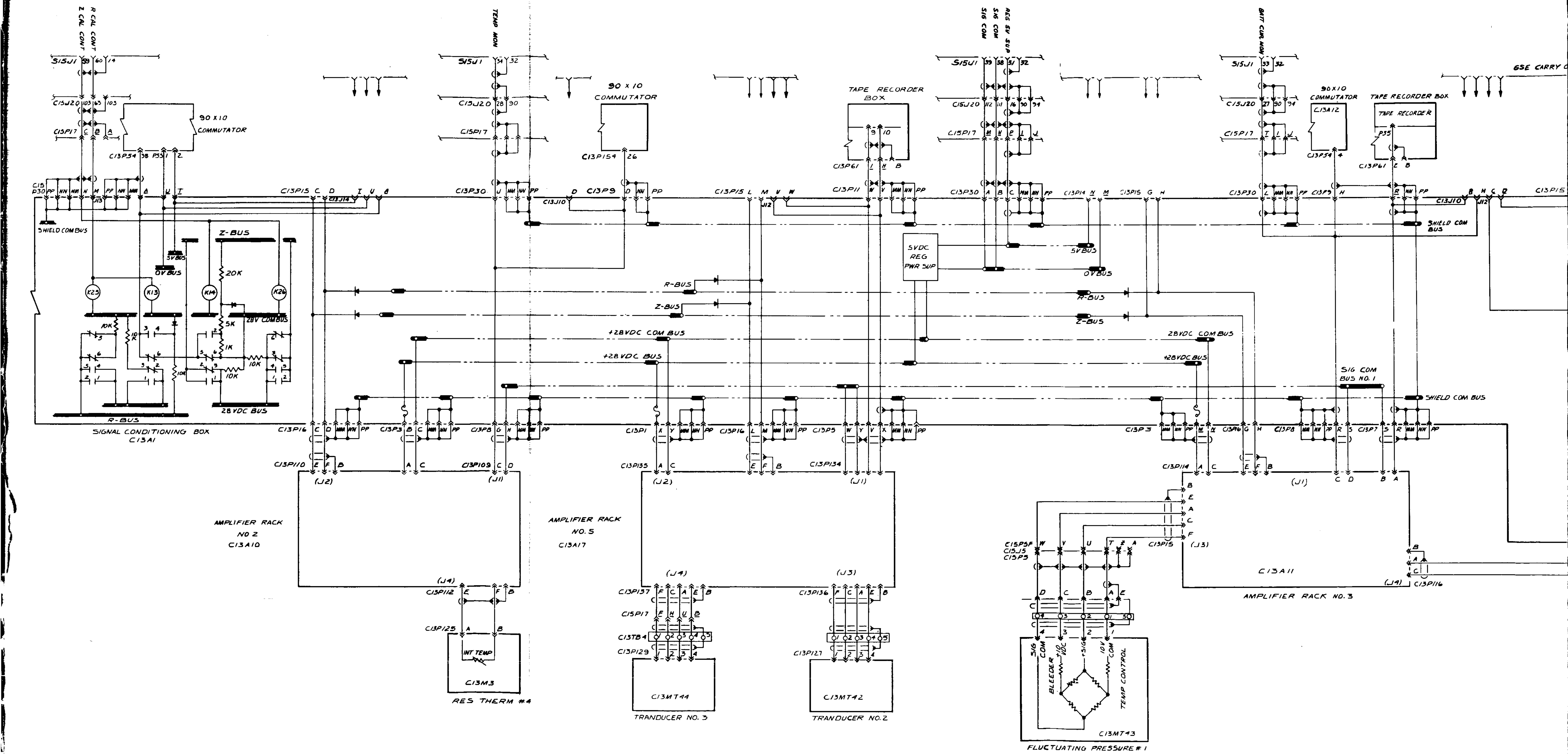
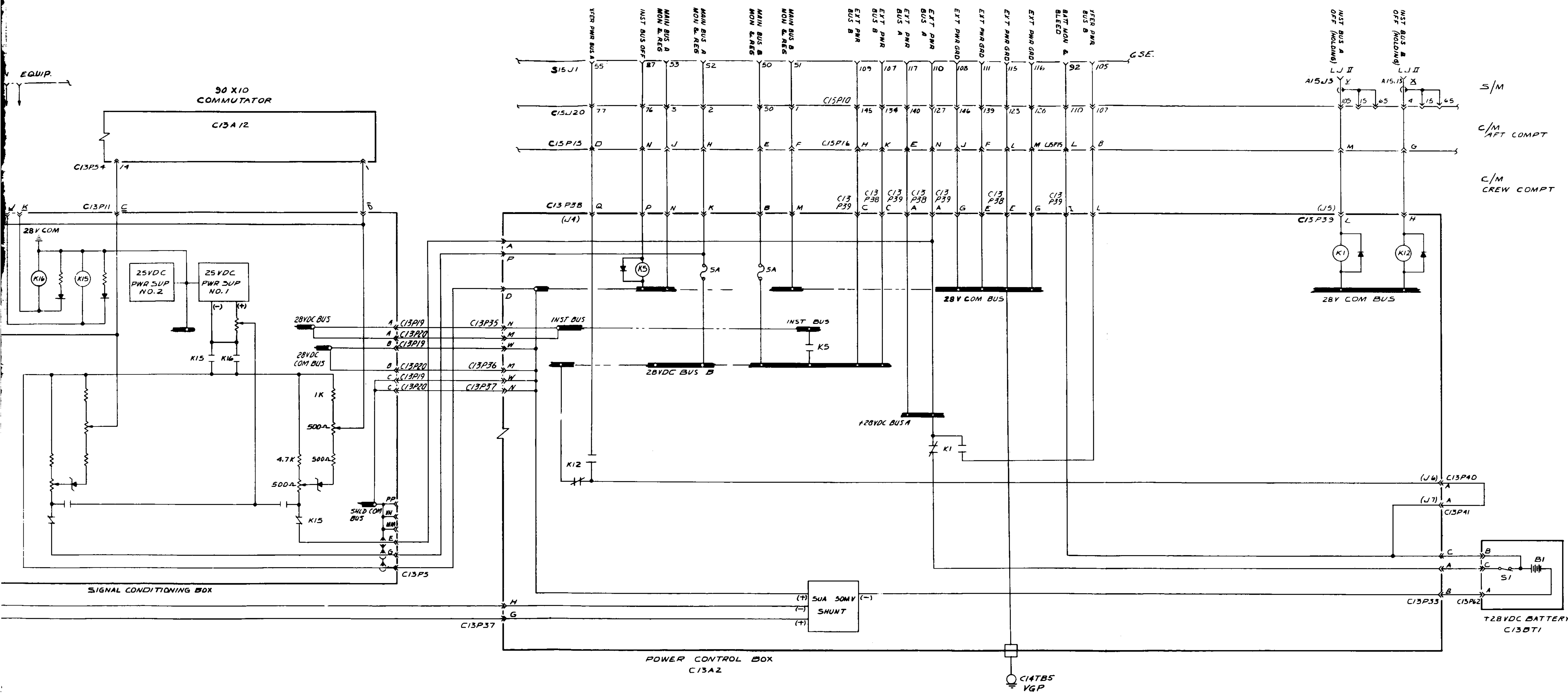


Figure 2-17. Pyrotechnic and Electromechanical Devices 28-Volt D-C Supply Block Diagram



R CAL CONT
Z CAL CONT
S15J1
C15J20
C15P17
90 X 10 COMMUTATOR
C13P34
P35
SHIELD COM BUS
5V BUS
0V BUS
Z-BUS
20K
5K
1K
10K
28V COMBUS
28VDC BUS
R-BUS
SIGNAL CONDITIONING BOX
C13A1
TEMP MON
C13P30
C13J10
C13P9
C13P154
C13P15
C13J14
TAPE RECORDER BOX
C13P61
C13P11
5VDC REG PWR SUP
R-BUS
Z-BUS
+28VDC COM BUS
+28VDC BUS
SIG COM
S/G COM
REG 5V SUP
C13P14
C13J12
5V BUS
0V BUS
28VDC COM BUS
+28VDC BUS
SIG COM BUS NO. 1
SHIELD COM BUS
BAT CUR MON
C13A12
TAPE RECORDER
GSE CARRY
C13P16
C13P3
C13P8
C13P1
C13P5
C13P7
C13P110
C13P109
C13P135
C13P134
C13P114
AMPLIFIER RACK NO 2
C13A10
AMPLIFIER RACK NO. 5
C13A17
C13P112
C13P125
INT TEMP
C13M3
RES THERM #4
C13P137
C15P17
C13TB4
C13P129
C13MT44
TRANDUCER NO. 3
C13P136
C13P127
C13MT42
TRANDUCER NO. 2
C15P5F
C15J5
C15P5
C13P15
C13A11
AMPLIFIER RACK NO. 3
C13P116
SIG COM
+10 VDC
+SIG
10V COM
BLEEDER
TEMP CONTROL
C13MT43
FLUCTUATING PRESSURE #1



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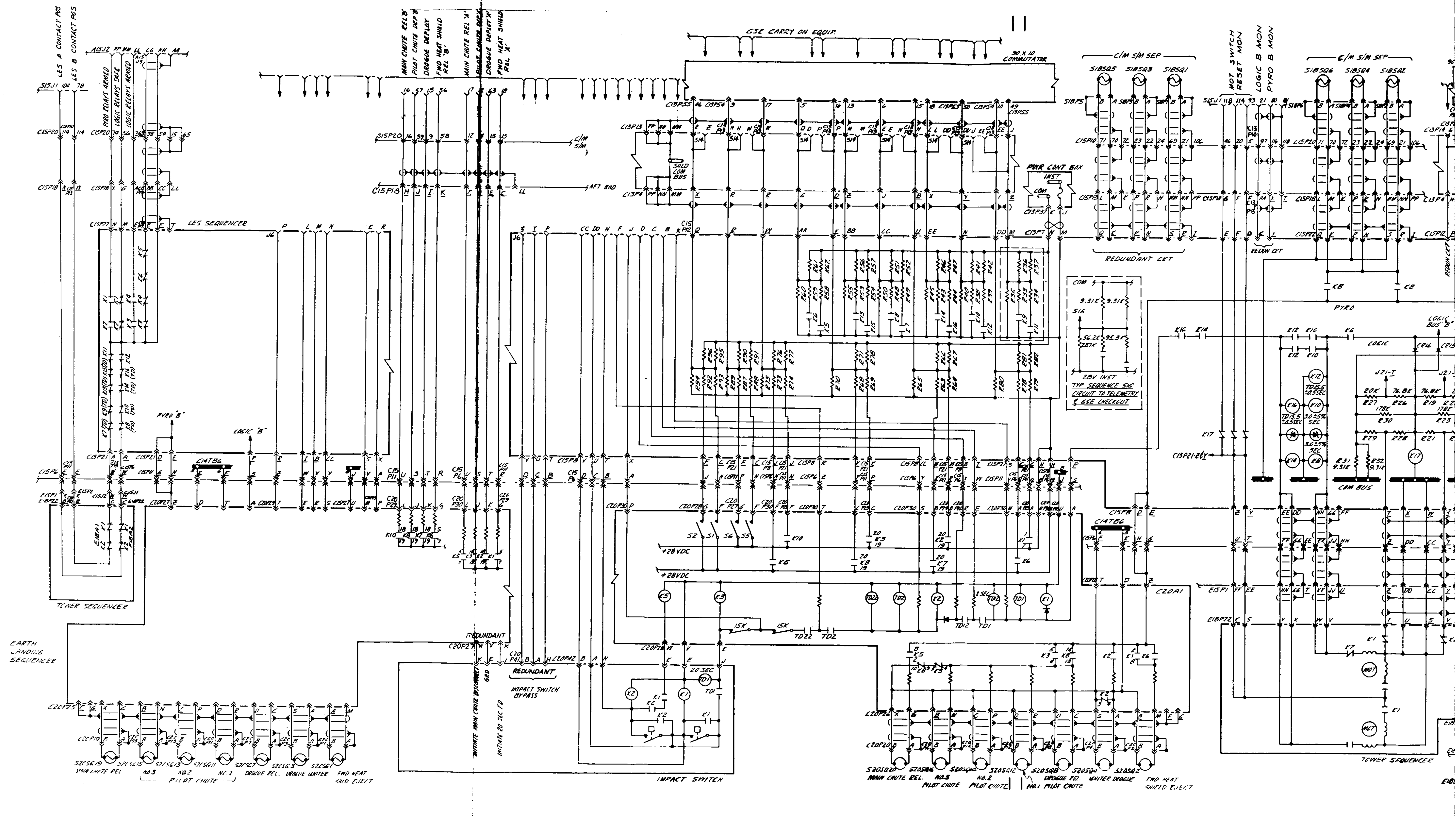
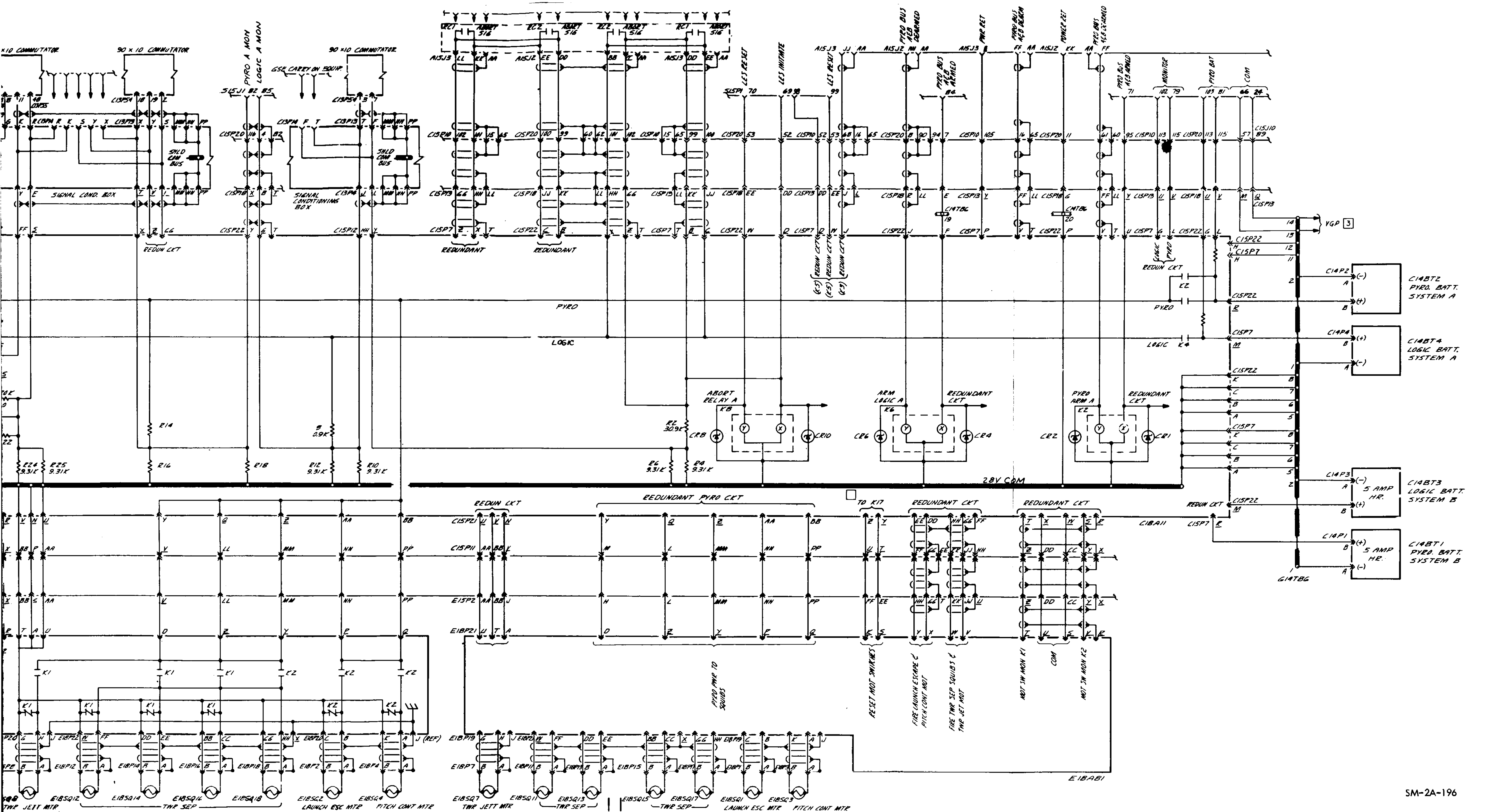
SM-2A-191

Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 1 of 9)



LES A CONTACT POS
LES B CONTACT POS
PYRO RELAYS ARMED
LOGIC RELAYS SAFE
LOGIC RELAYS ARMED
LES SEQUENCER
TOWER SEQUENCER
EARTH LANDING SEQUENCER
MAIN CHUTE REL 'B'
PILOT CHUTE DEP 'B'
DROGUE DEPLOY
FWD HEAT SHIELD REL 'B'
MAIN CHUTE REL 'A'
PILOT CHUTE DEP 'A'
DROGUE DEPLOY 'A'
FWD HEAT SHIELD REL 'A'
GSE CARRY ON EQUIP.
90 X 10 COMMUTATOR
SHLD COM BUS
PWR CONT BOX
C/M S/M SEP
REDUNDANT CKT
REDUN CKT
MOT SWITCH RESET MON
LOGIC B MON
PYRO B MON
TYP SEQUENCE SIG CIRCUIT TO TELEMETRY & GSE CHECKOUT
28V INST
PYRO
LOGIC
LOGIC BUS 'B'
COM BUS
PYRO 'B'
LOGIC 'B'
+28VDC
REDUNDANT
IMPACT SWITCH BYPASS
INITIATE MAIN CHUTE DISCONNECT
INITIATE 20 SEC TD
IMPACT SWITCH
MAIN CHUTE REL
PILOT CHUTE
DROGUE REL.
DROGUE IGNITER
FWD HEAT SHLD EJECT
MAIN CHUTE REL.
PILOT CHUTE
DROGUE REL.
IGNITER DROGUE
FWD HEAT SHIELD EJECT



SM-2A-196

Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 2 of 9)

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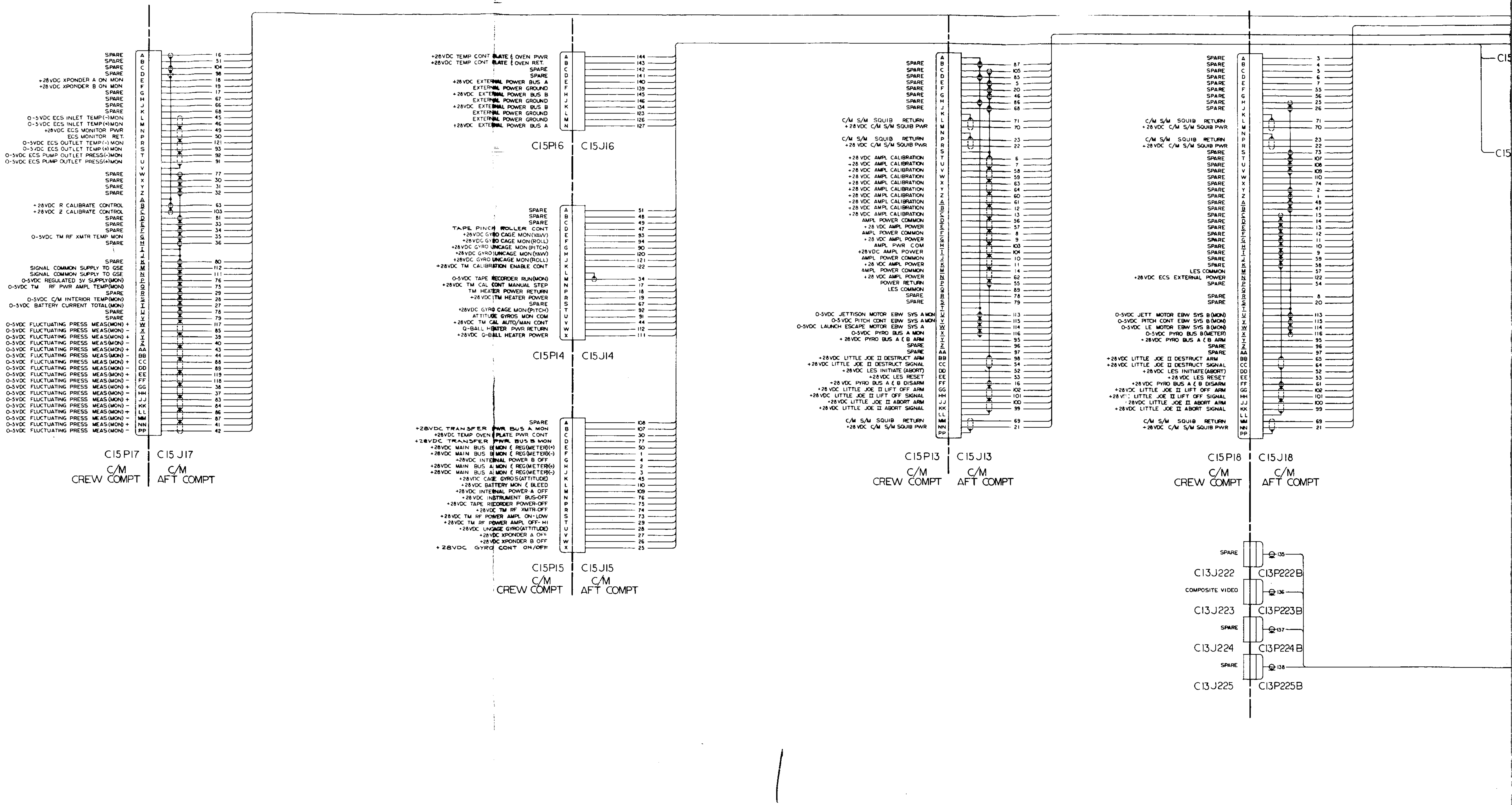
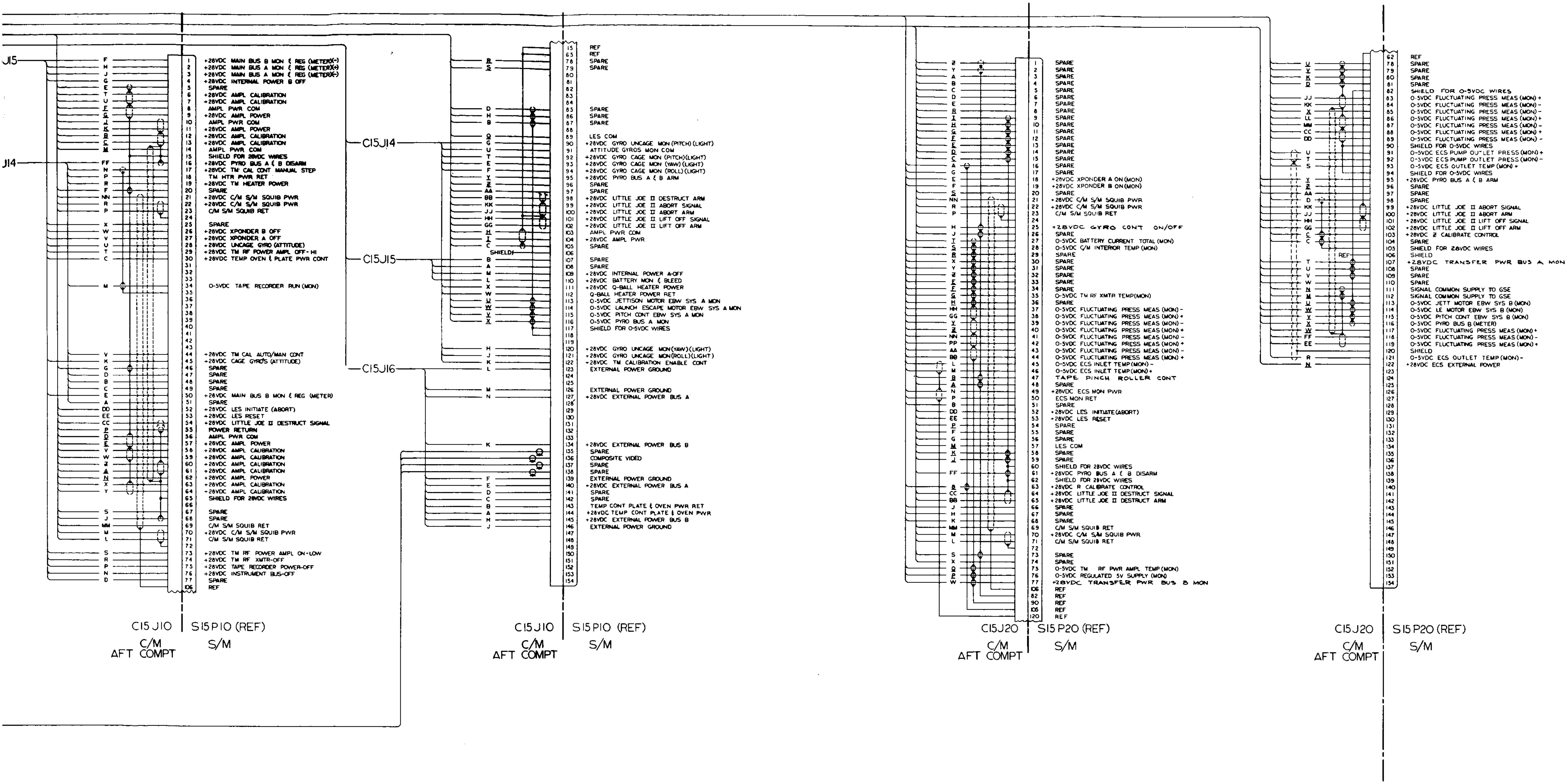


C15P17
C15J17
C/M CREW COMPT
C/M AFT COMPT
C15P16
C15J16
C15P14
C15J14
C15P15
C15J15
C/M CREW COMPT
C/M AFT COMPT
C15P13
C15J13
C/M CREW COMPT
C/M AFT COMPT
C15P18
C15J18
C/M CREW COMPT
C/M AFT COMPT
SPARE
C13J222
C13P222B
COMPOSITE VIDEO
C13J223
C13P223B
SPARE
C13J224
C13P224B
SPARE
C13J225
C13P225B



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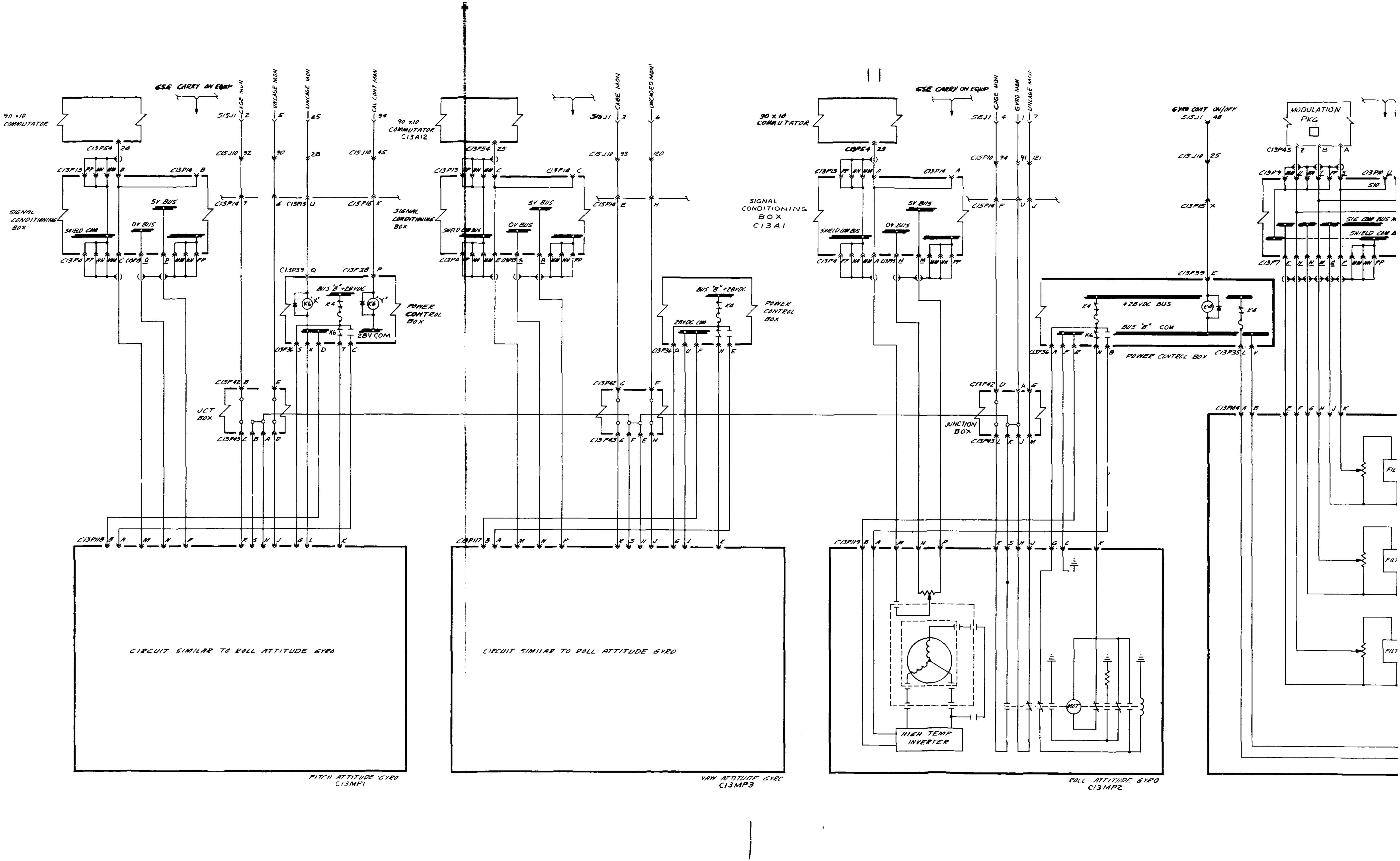
SM-2A-197

Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 3 of 9)


GSE CARRY ON EQUIP
90 x 10 COMMUTATOR
SIGNAL CONDITIONING BOX
SHIELD COM
5V BUS
0V BUS
CAGE MON
UNCAGE MON
CAL CONT MAN
POWER CONTROL BOX
BUS "B" +28VDC
28V COM
JCT BOX
90 x 10 COMMUTATOR C13A12
28VDC COM
SIGNAL CONDITIONING BOX C13A1
GYRO MON
JUNCTION BOX
GYRO CONT ON/OFF
+28VDC BUS
BUS "B" COM
MODULATION PKG
SIG COM BUS
SHIELD COM BUS
CIRCUIT SIMILAR TO ROLL ATTITUDE GYRO
PITCH ATTITUDE GYRO C13MP1
YAW ATTITUDE GYRO C13MP3
HIGH TEMP INVERTER
MOT
ROLL ATTITUDE GYRO C13MP2

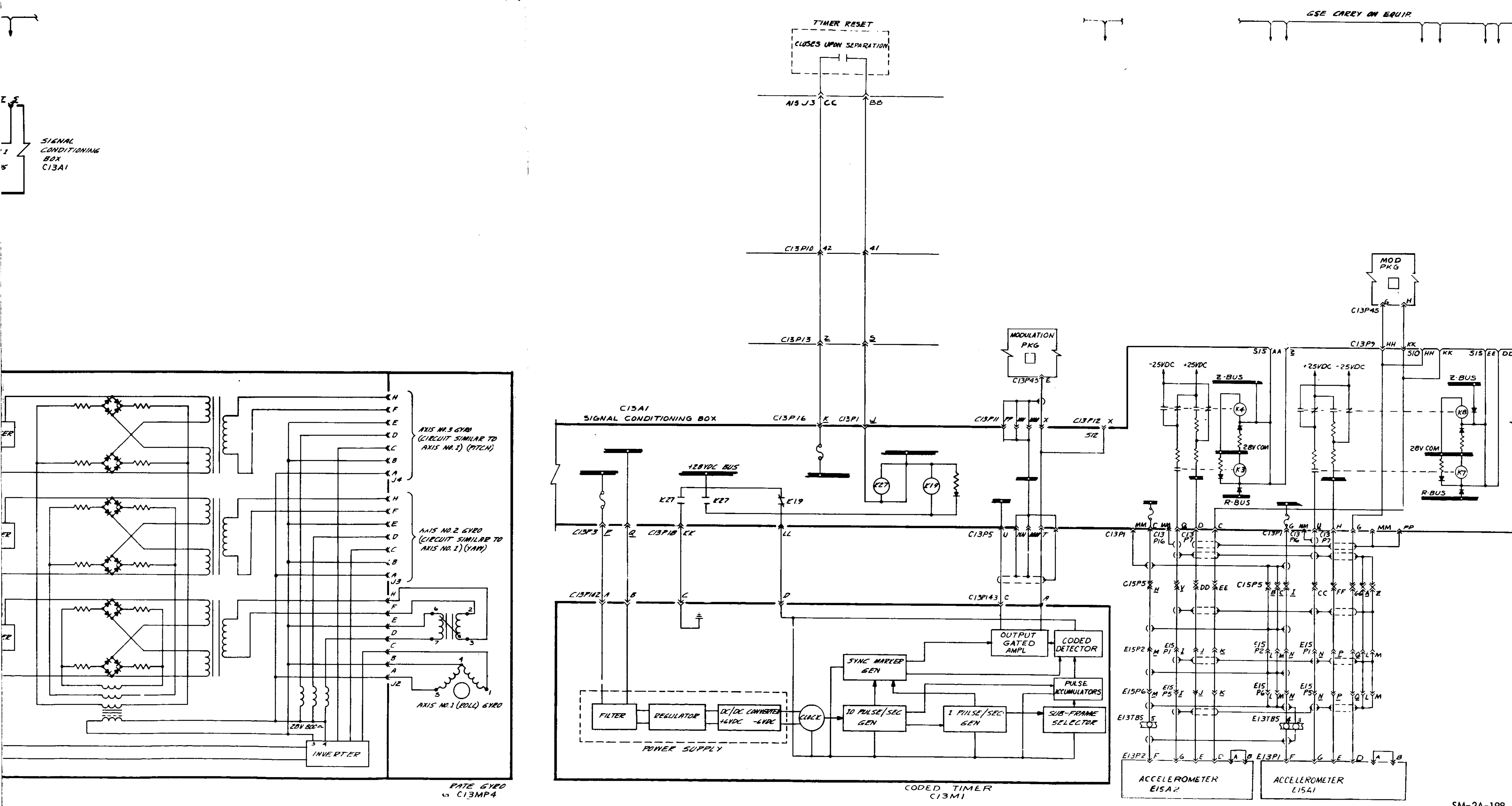
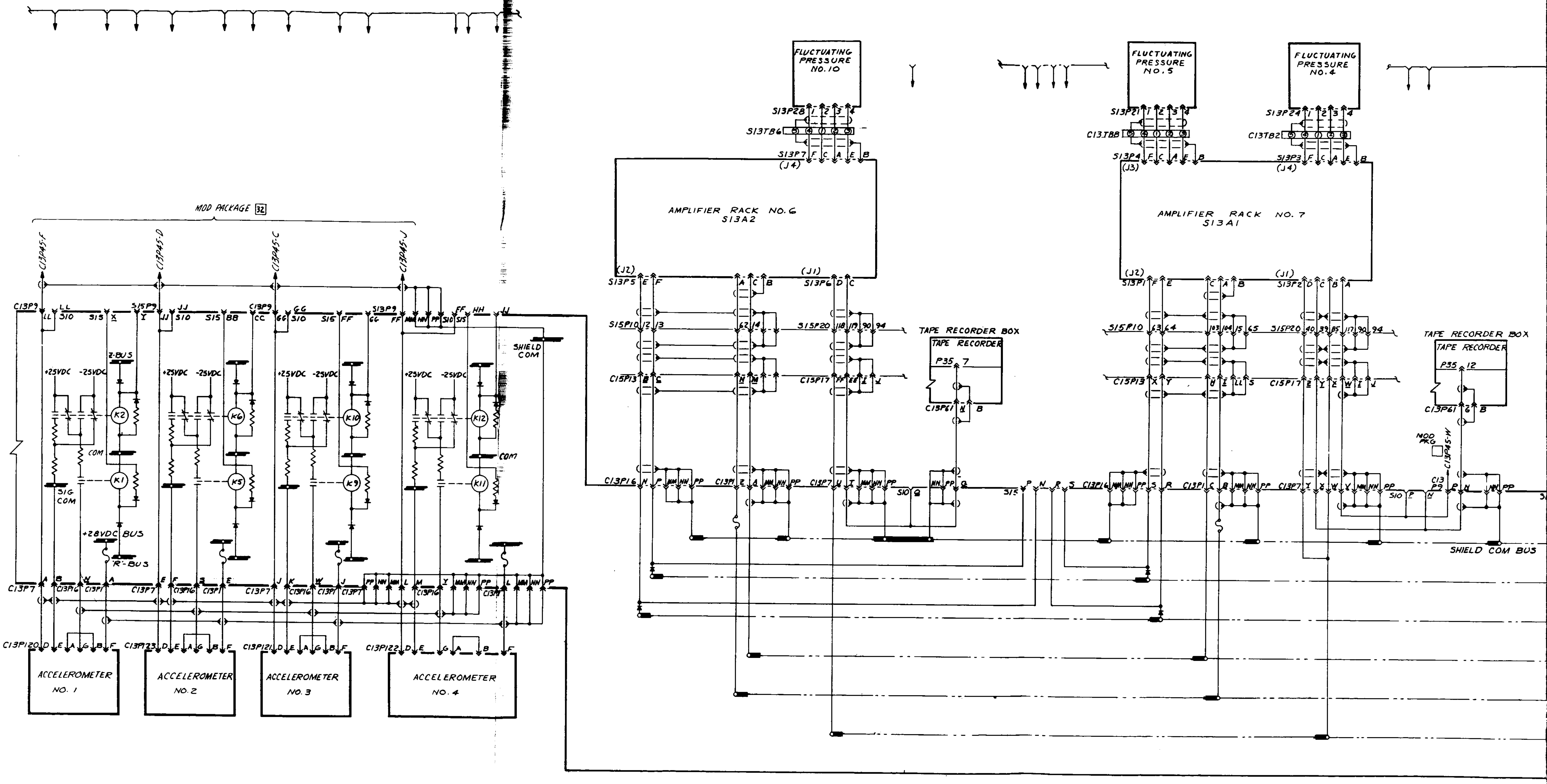
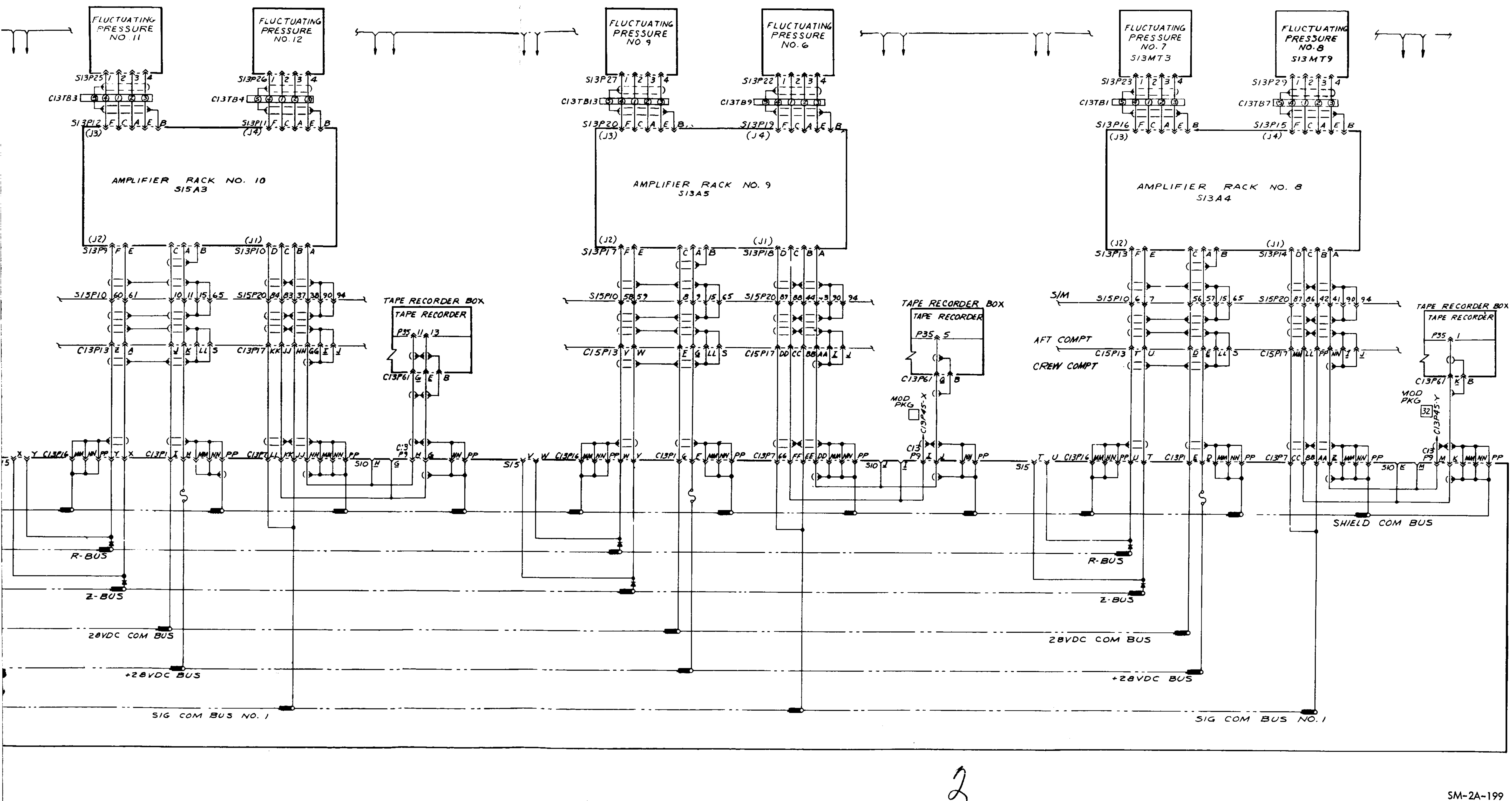


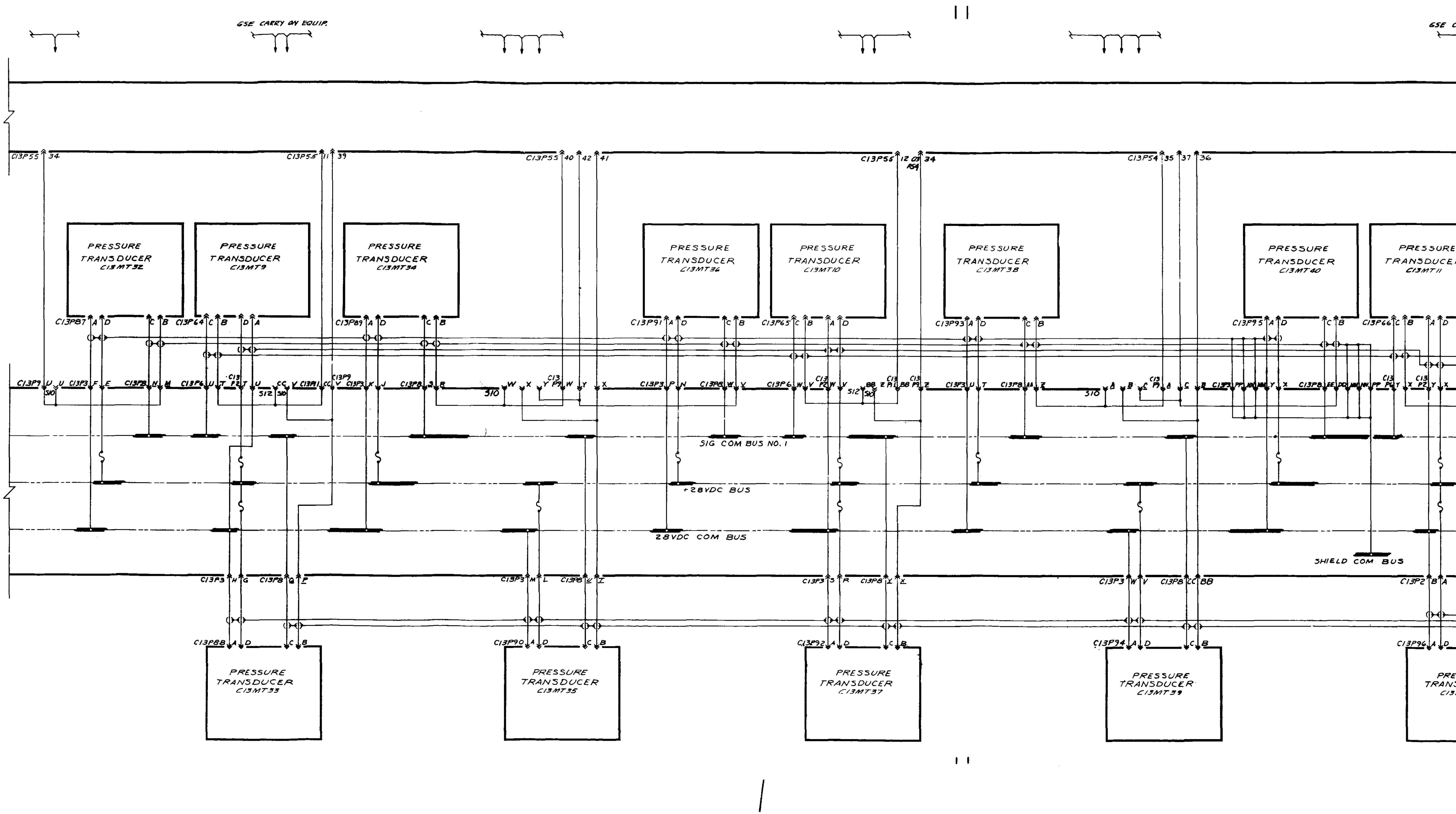
Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 4 of 9)


MOD PACKAGE 32
C13P45-F
C13P45-D
C13P45-C
C13P45-J
+25VDC
-25VDC
Z-BUS
SIG COM
COM
+28VDC BUS
R-BUS
SHIELD COM
ACCELEROMETER NO. 1
ACCELEROMETER NO. 2
ACCELEROMETER NO. 3
ACCELEROMETER NO. 4
FLUCTUATING PRESSURE NO. 10
FLUCTUATING PRESSURE NO. 5
FLUCTUATING PRESSURE NO. 4
S13TB6
C13TB8
C13TB2
AMPLIFIER RACK NO. 6 S13A2
AMPLIFIER RACK NO. 7 S13A1
TAPE RECORDER BOX
TAPE RECORDER
P35 7
P35 12
C13P61
MOD PKG
C13P45-W
SHIELD COM BUS



SM-2A-199

Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 5 of 9)



GSE CARRY ON EQUIP.
PRESSURE TRANSDUCER C13MT32
PRESSURE TRANSDUCER C13MT9
PRESSURE TRANSDUCER C13MT34
PRESSURE TRANSDUCER C13MT36
PRESSURE TRANSDUCER C13MT10
PRESSURE TRANSDUCER C13MT38
PRESSURE TRANSDUCER C13MT40
PRESSURE TRANSDUCER C13MT11
PRESSURE TRANSDUCER C13MT33
PRESSURE TRANSDUCER C13MT35
PRESSURE TRANSDUCER C13MT37
PRESSURE TRANSDUCER C13MT39
SIG COM BUS NO. 1
+28VDC BUS
28VDC COM BUS
SHIELD COM BUS

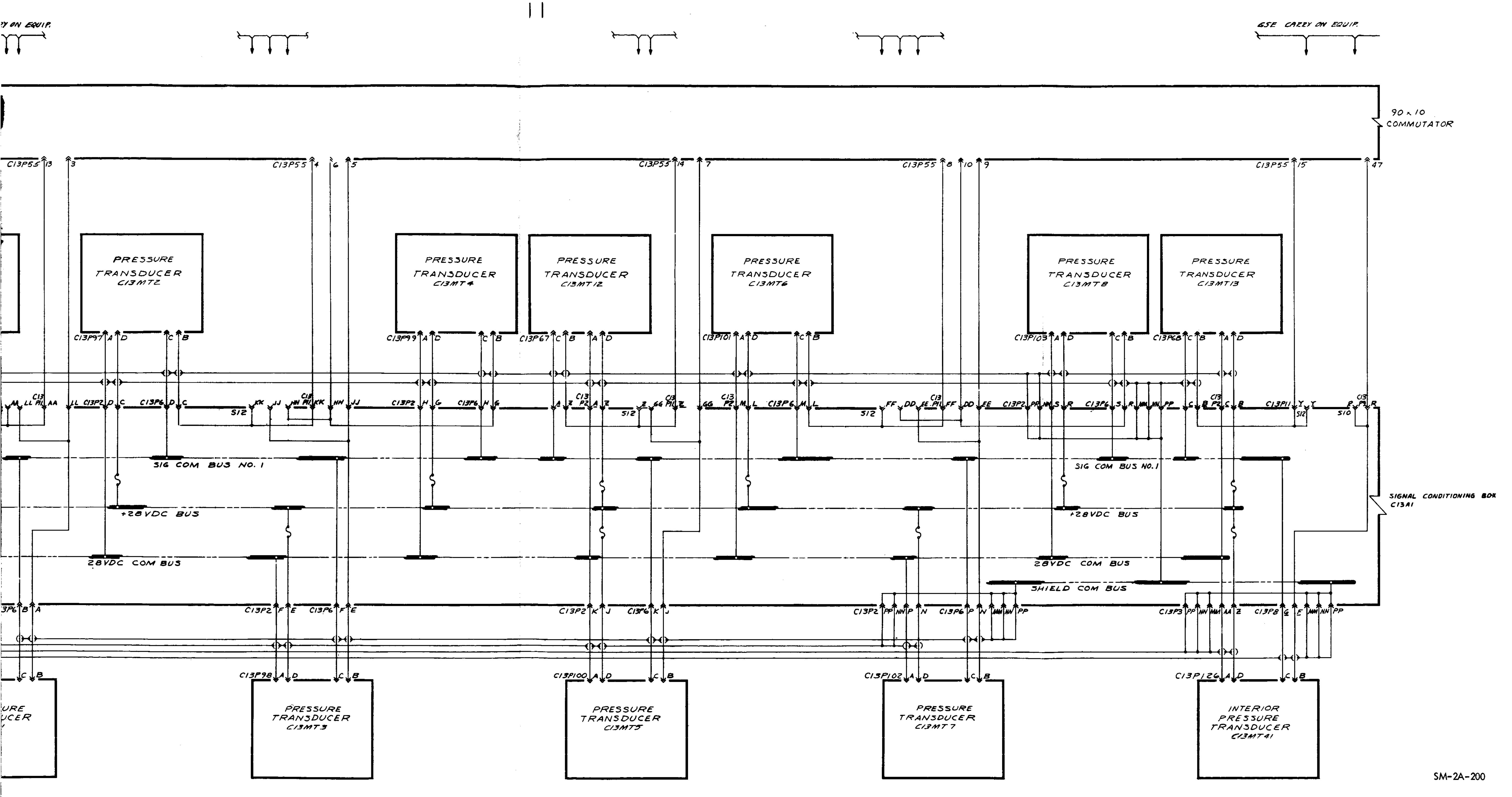


Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 6 of 9)

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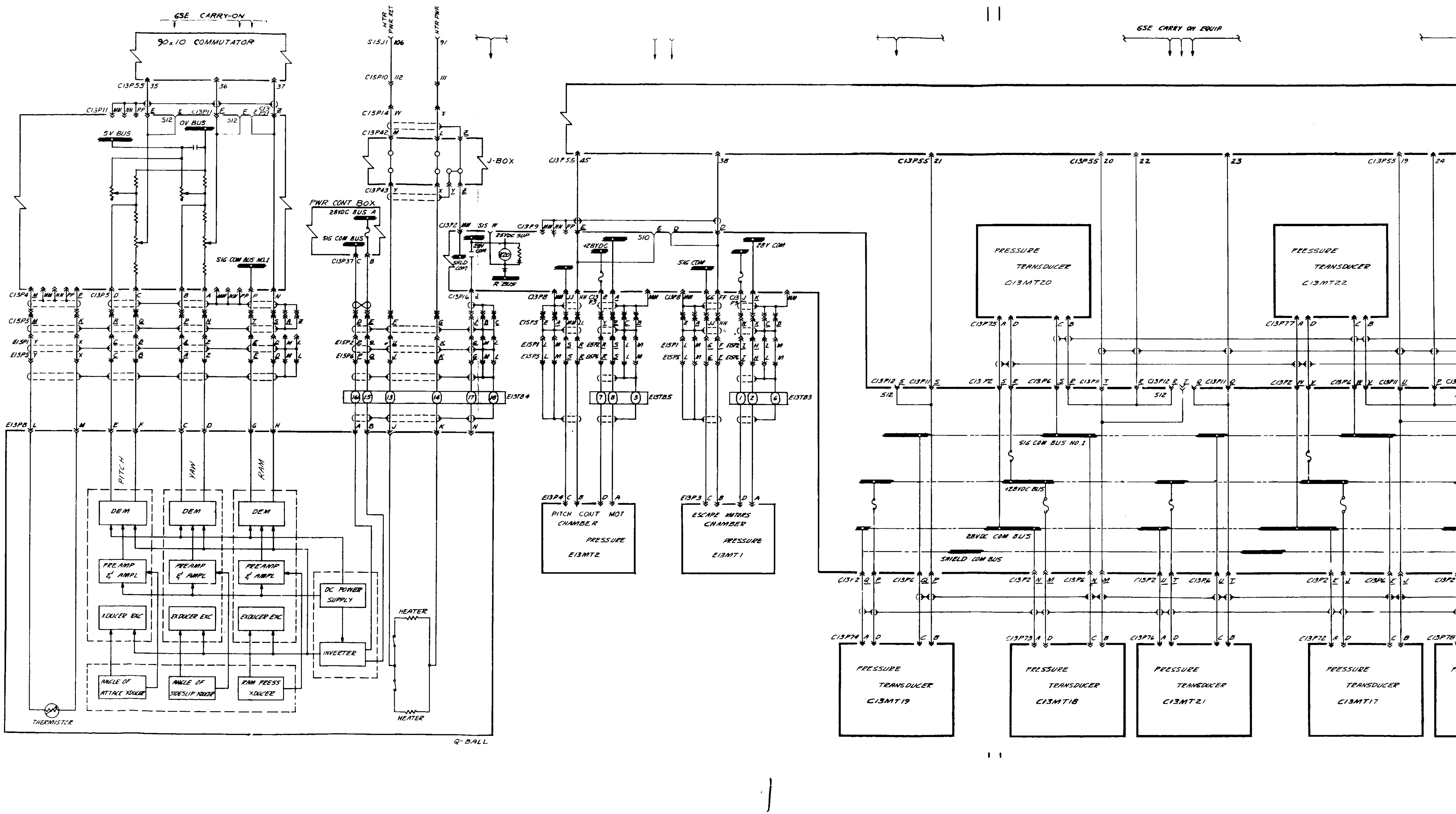


GSE CARRY-ON
90 x 10 COMMUTATOR
5V BUS
0V BUS
SIG COM BUS NO.1
J-BOX
PWR CONT BOX
28VDC BUS A
SIG COM BUS
HTR PWR RET
HTR PWR
+28VDC
28V COM
SIG COM
R BUS
PITCH
YAW
RAM
DEM
PREAMP & AMPL
XDUCER EXC
ANGLE OF ATTACK XDUCER
ANGLE OF SIDESLIP XDUCER
RAM PRESS XDUCER
DC POWER SUPPLY
INVERTER
HEATER
THERMISTOR
Q-BALL
PITCH CONT MOT CHAMBER PRESSURE E13MT2
ESCAPE MOTORS CHAMBER PRESSURE E13MT1
GSE CARRY ON EQUIP
PRESSURE TRANSDUCER C13MT20
PRESSURE TRANSDUCER C13MT22
SIG COM BUS NO.1
+28VDC BUS
28VDC COM BUS
SHIELD COM BUS
PRESSURE TRANSDUCER C13MT19
PRESSURE TRANSDUCER C13MT18
PRESSURE TRANSDUCER C13MT21
PRESSURE TRANSDUCER C13MT17

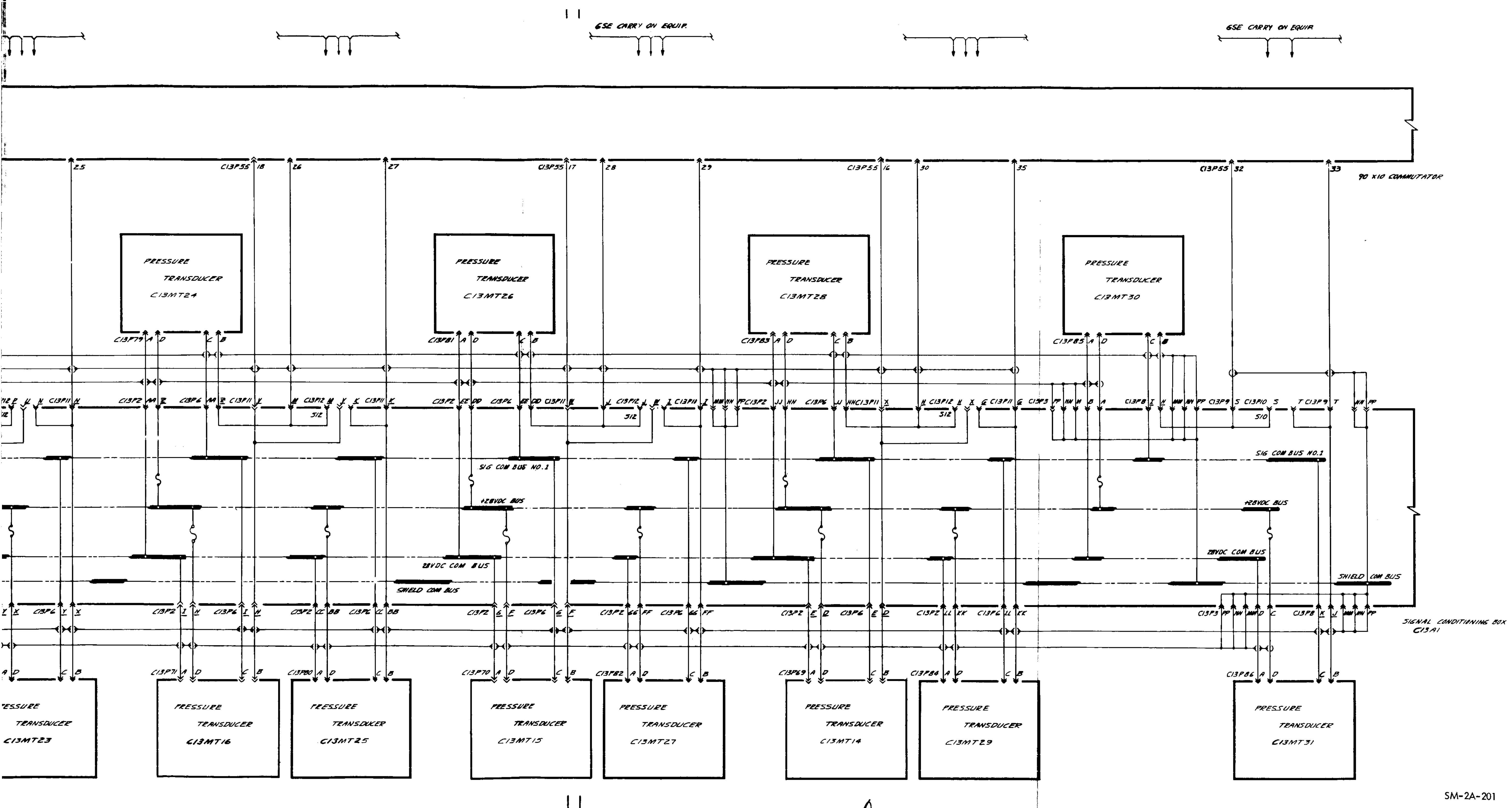
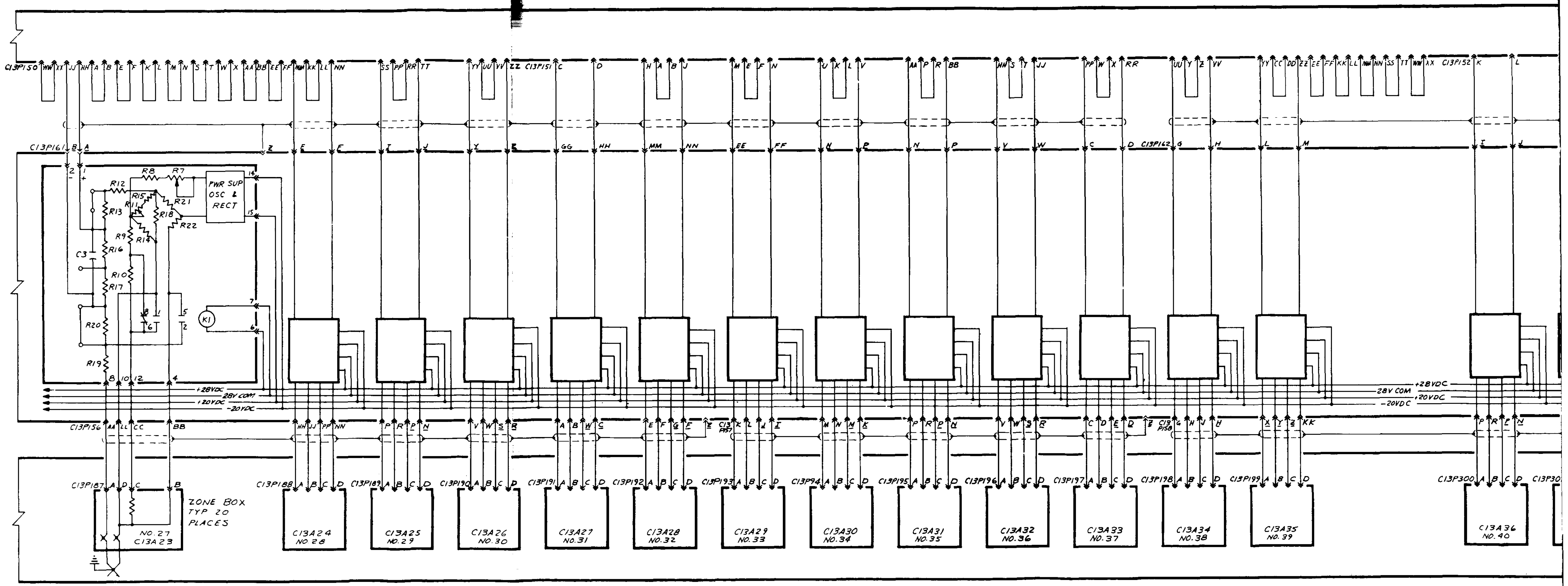


Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 7 of 9)


C13P150
C13P151
C13P152
C13P161
C13P162
PWR SUP
OSC &
RECT
K1
+28VDC
28V COM
+20VDC
-20VDC
C13P156
C13P187
ZONE BOX
TYP 20
PLACES
NO. 27
C13A23
C13A24
NO. 28
C13A25
NO. 29
C13A26
NO. 30
C13A27
NO. 31
C13A28
NO. 32
C13A29
NO. 33
C13A30
NO. 34
C13A31
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NO. 37
C13A34
NO. 38
C13A35
NO. 39
C13A36
NO. 40

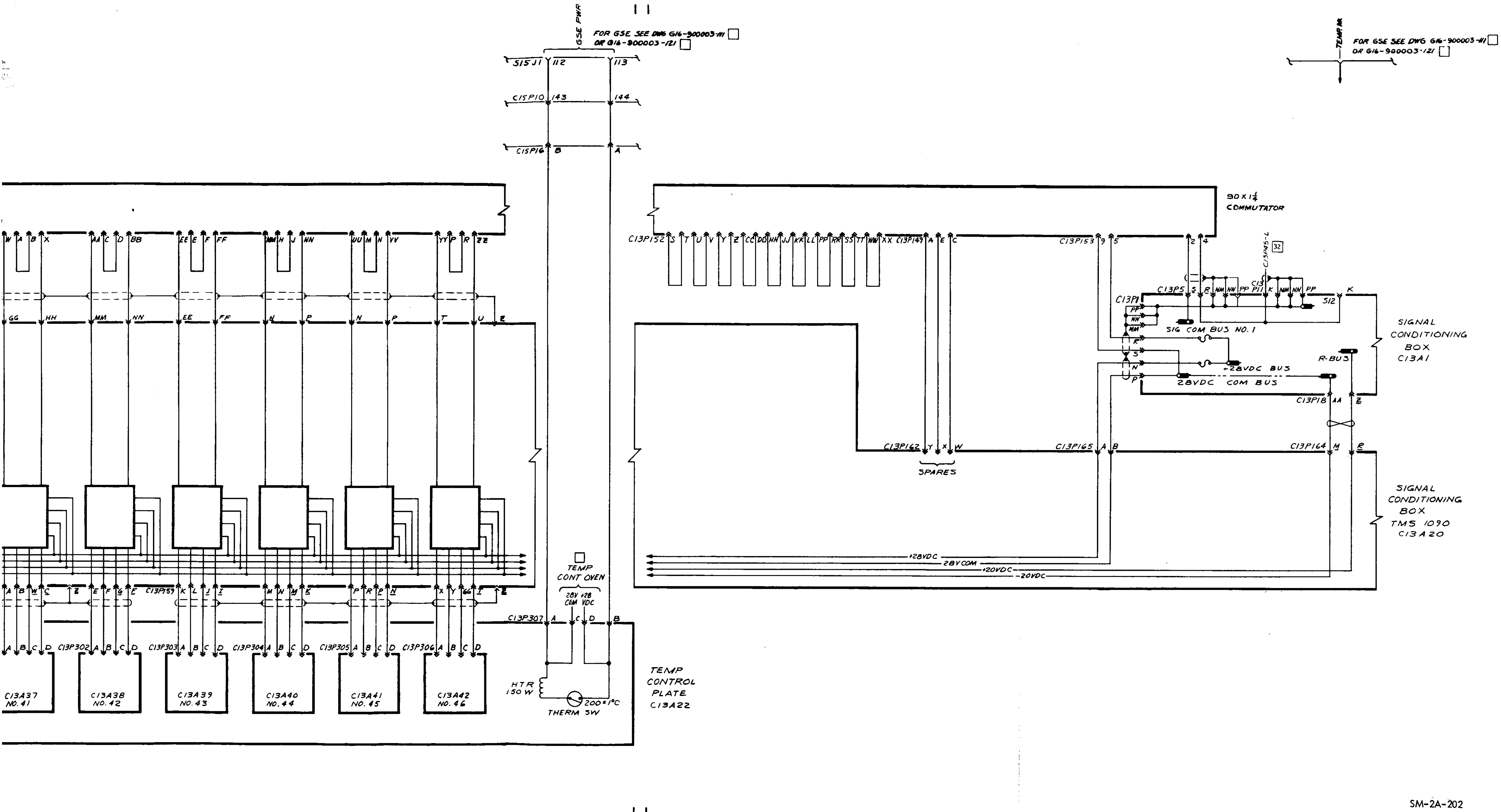

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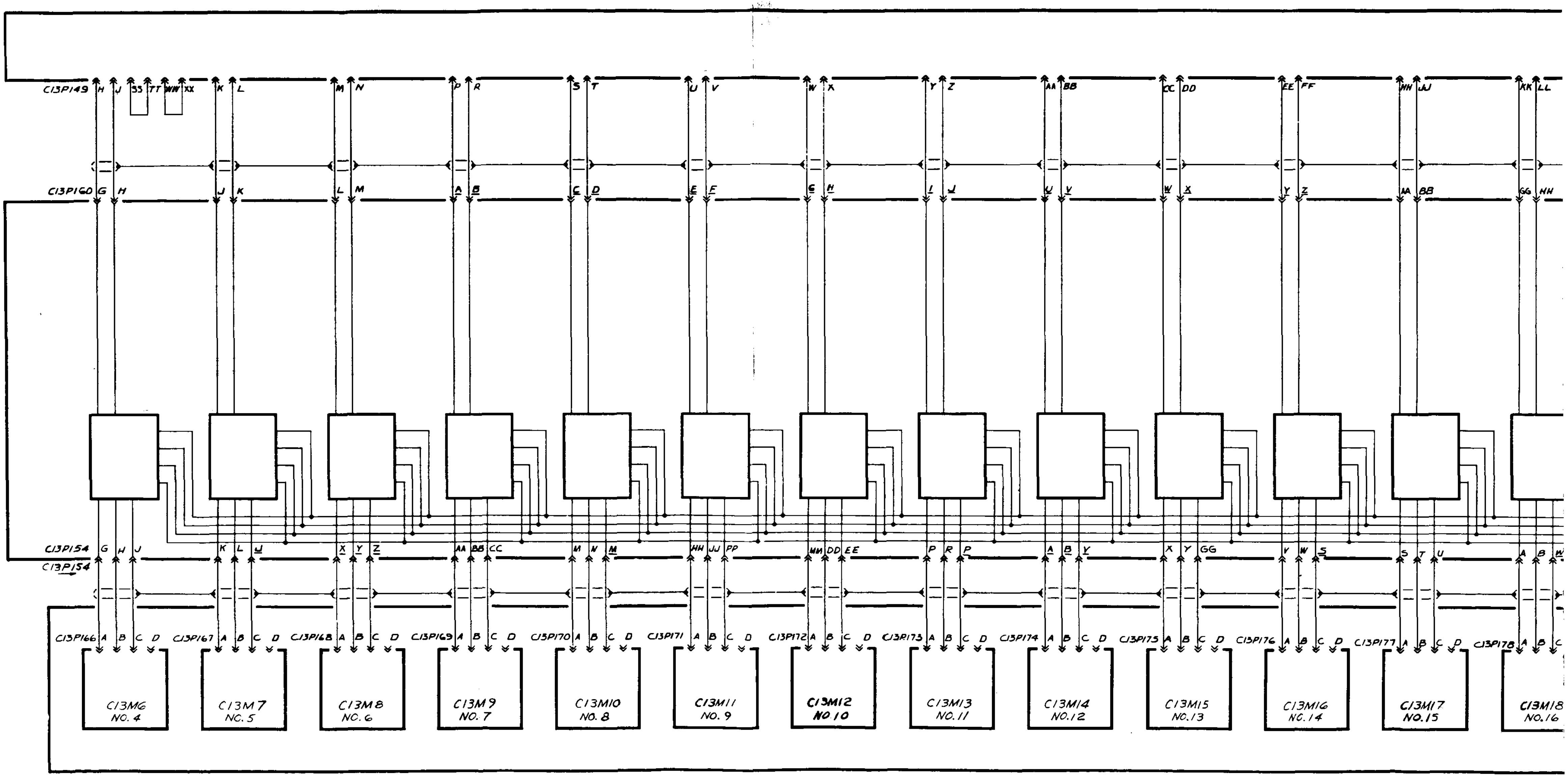
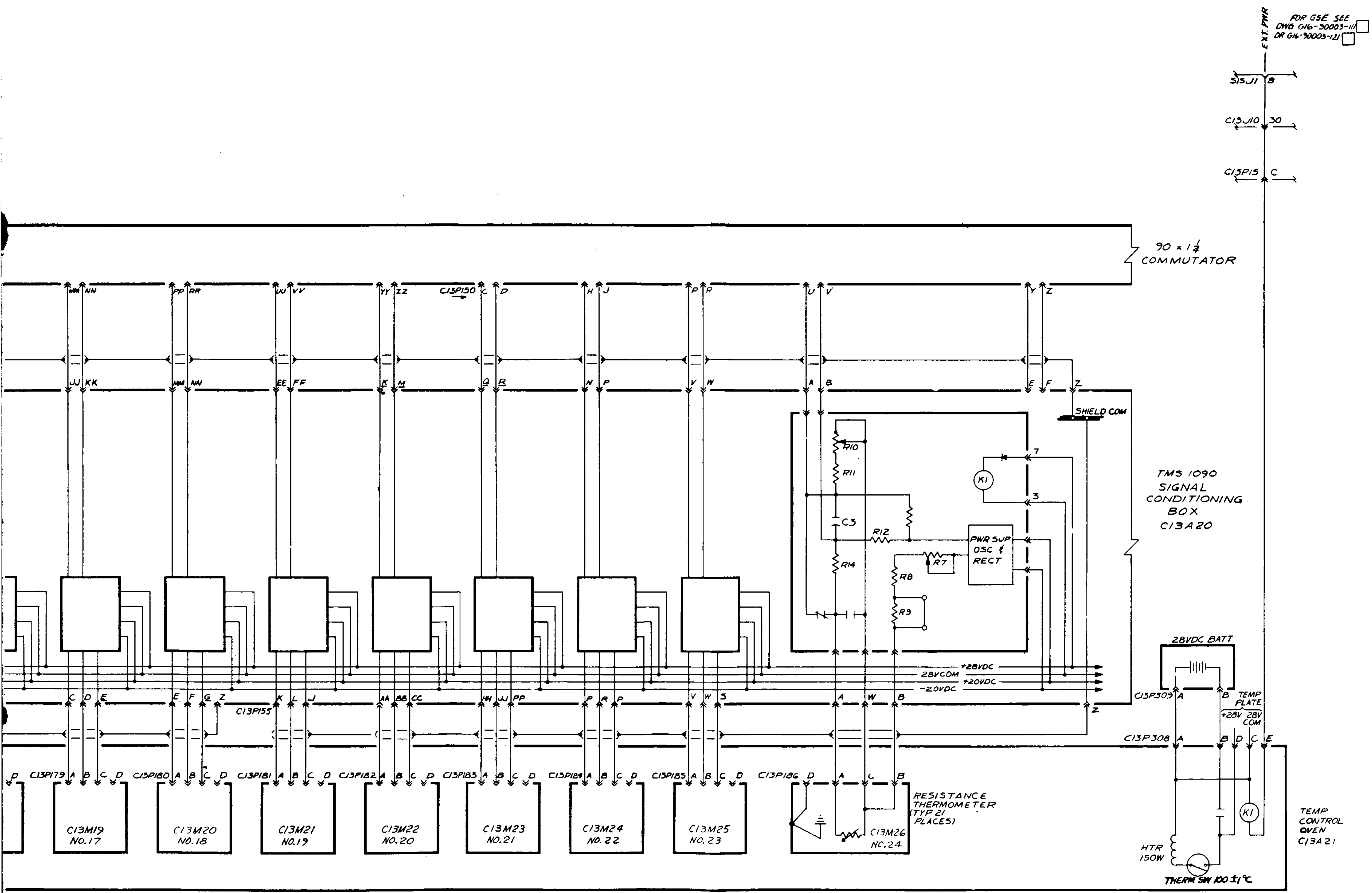
Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 8 of 9)


C13P149
C13P160
C13P154
C13P154
C13P166
C13P167
C13P168
C13P169
C13P170
C13P171
C13P172
C13P173
C13P174
C13P175
C13P176
C13P177
C13P178
C13M6 NO. 4
C13M7 NO. 5
C13M8 NO. 6
C13M9 NO. 7
C13M10 NO. 8
C13M11 NO. 9
C13M12 NO 10
C13M13 NO. 11
C13M14 NO. 12
C13M15 NO. 13
C13M16 NO. 14
C13M17 NO. 15
C13M18 NO. 16



SM-2A-203

Figure 2-18. Boilerplate 12 Schematic Diagram (Sheet 9 of 9)

SECTION III

LAUNCH ESCAPE SYSTEM

3-1. PURPOSE.

3-2. This prototype launch escape assembly serves to qualify the basic design and engineering concepts of the launch escape system to be used throughout the Apollo program. (See figure 2-1.) The purpose of the production-type launch escape system is to translate the command module away from the launch escape vehicle in the event that a malfunction endangers the Apollo crew.

3-3. OPERATIONAL DESCRIPTION.

3-4. The launch escape system for boilerplate 12 operates in a series of controlled steps commencing when an abort command signal is received. Figure 3-1 is a functional block diagram showing the time sequence of pertinent events. Figure 3-2 is an electrical schematic diagram of the launch escape system. Figure 3-3 is a wiring diagram of the launch escape system. Table 3-1 is a time history of the events of the launch escape system.

Table 3-1. Calculated Time for LES Test-Events

Time After Launch (sec)	Event
T+0.0	Logic bus arm Pyro bus arm Escape motor arm Pitch control motor arm Jettison motor arm Booster ignition and launch
T+29.0	Abort command (radio signal) Command module and service module separation Launch escape motor ignition Pitch control motor ignition Initiate tower separation relay (15.5 sec time delay) Arm jettison motor
T+44.5	Fire pyrotechnic bolts Tower jettison motor ignition Initiate ELS relay

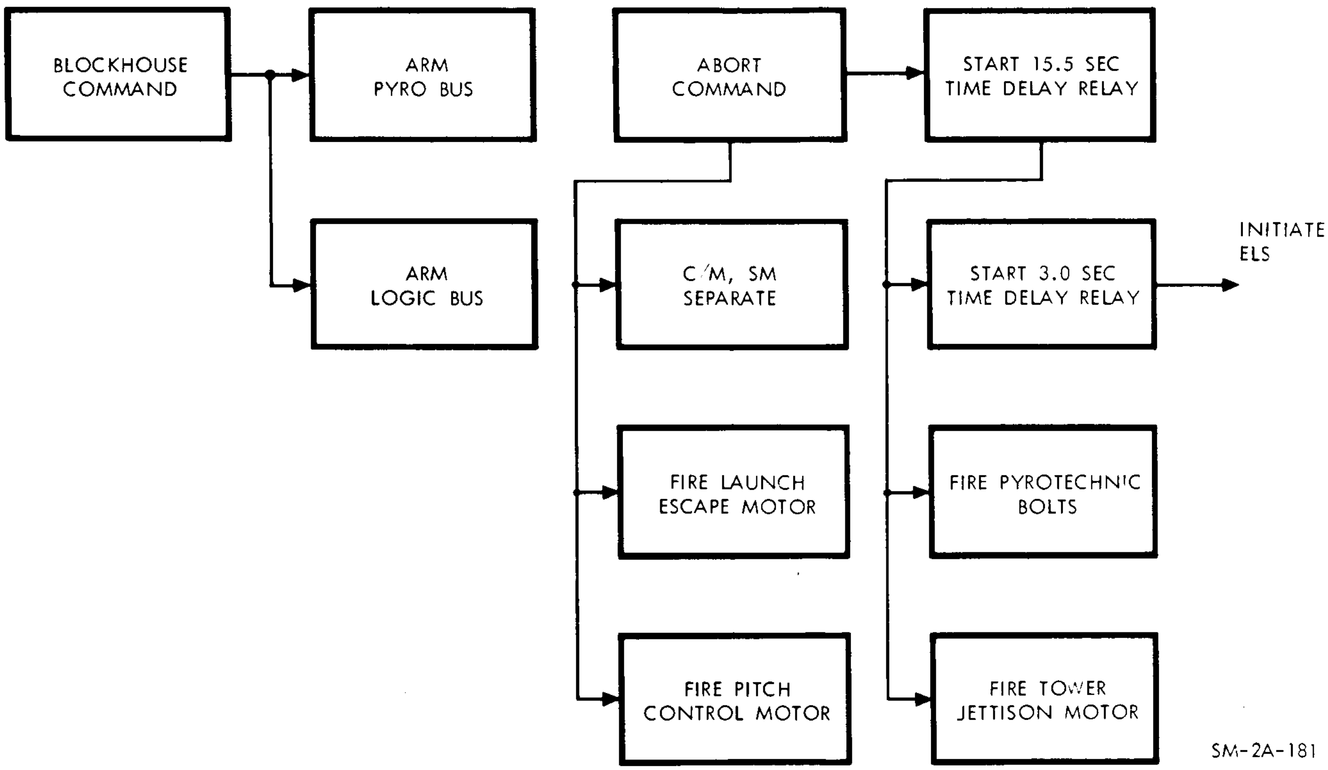


Figure 3-1. Launch Escape System Abort Sequence Control Block Diagram

Table 3-1. Calculated Time for LES Test-Events (Cont)

Time After Launch (sec)	Event
T+47.5	Forward heat shield separation
T+48.5	Recovery sequence start

3-5. The sequence steps cannot be speeded up or delayed in flight. The abort sequence is initiated at T+29.0 seconds. At this time dynamic pressure has reached a (q) value of approximately 614 pounds per square foot and the altitude is approximately 20,000 feet above sea level. Table 3-2 contains the flight parameters.

Table 3-2. WSMR Flight Parameters - No Wind Condition

Flight Sequence	Time After Launch	Altitude Feet, MSL	Range Feet	Velocity Feet/Sec	Flight Path Angle, Degrees	Dynamic Pressure
Booster ignition and launch	T+0.0	4,000	0000	0000	+82	0000
Abort initiation, escape motor ignition, and pitch control motor ignition	T+29.0	18,000	8,200	941	+45.8	600
Tower jettison	T+44.5	24,000	19,600	476	+2.4	125
Recovery sequence start	T+48.5	23,800	21,200	370	-13.6	76

3-6. ROCKET MOTOR IGNITION. (See figure 3-2.)

3-7. Each of the LES motor ignition networks contains an igniter and two HBW initiators. Redundant initiators are employed for reliability. The hot bridge wire initiators will ignite within 10 milliseconds after application of a firing current of 3.5 amperes at 28 volts dc. When ignition of a particular motor is required, the sequencer applies the current required to detonate the initiator thereby igniting the igniter and the motor. The igniter for the launch escape motor extends into the center of the motor case approximately 25 inches. The escape motor igniter propellant contains an inner grain which is circular and an outer grain which is a 20-point configuration. The pellets are of boron potassium nitrate. The igniter for the tower jettison motor is threaded for installation in the aft dome of the rocket motor. The pellets are boron potassium nitrate. The propellant grain is an 8-point configuration. The igniter for the pitch control motor extends into the motor approximately 2 inches. The pellets are boron potassium nitrate, and a total of 40 grains is contained in the ignitor body by the cap. HBW initiators are installed in the outside cover flange of each igniter.

3-8. TOWER SEPARATION.

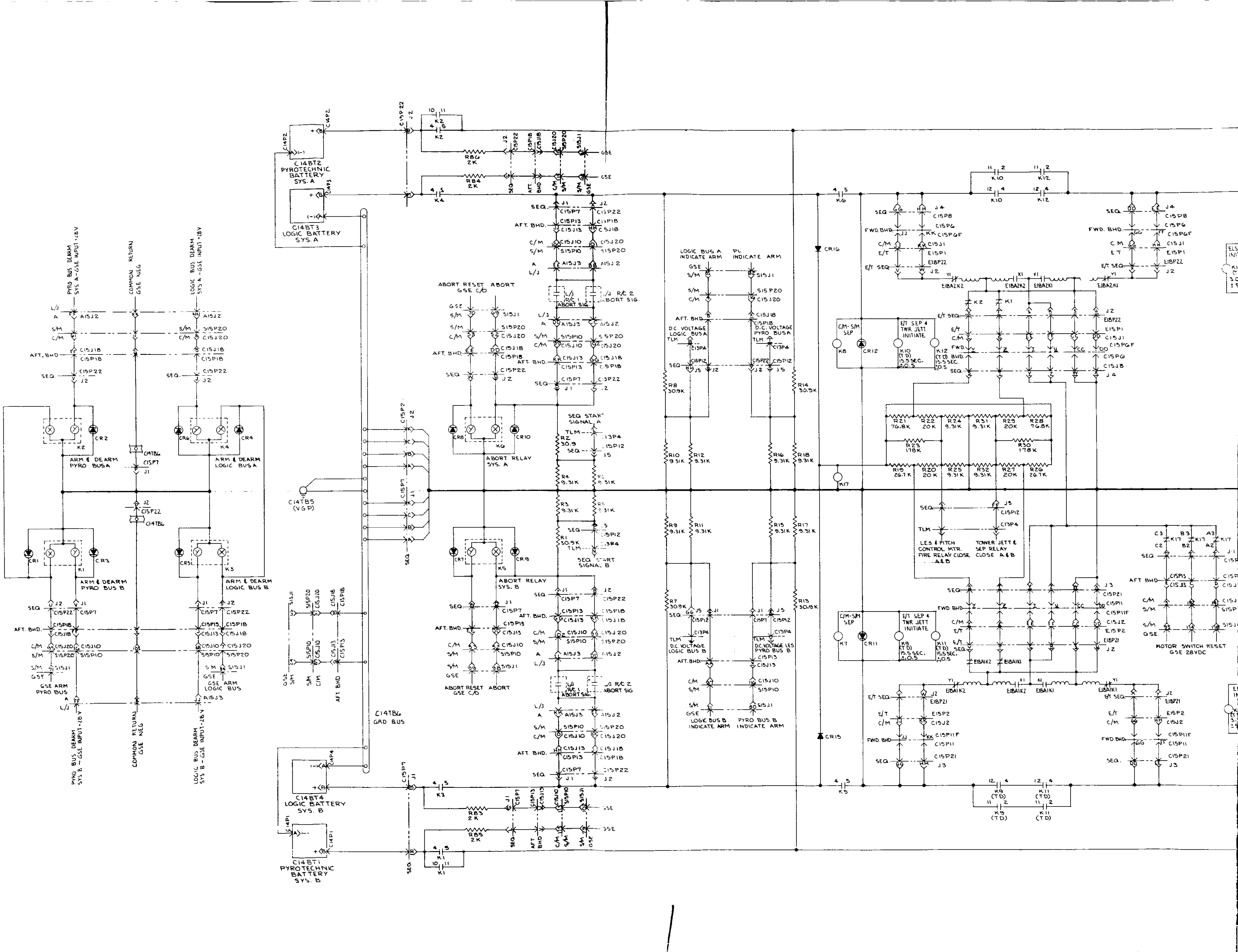
3-9. The tower separation system consists of four pyrotechnic bolt assemblies that attach the tower to the command module. (See figure 2-2.) The bolts are made in two sections which are threaded and screwed together. An explosive charge placed at the threaded joint is ignited by a squib to shatter the connection. The upper section of the bolt assembly is flattened to accept a shaped-explosive cutting charge. The charge is squib-fired to sever the bolt at that point, thus providing bolt destruction redundancy. Release of the tower is accomplished by simultaneous destruction of the four pyrotechnic bolts. Hot bridge wire initiators actuated by 28-volt d-c current received from the tower sequencers will detonate the explosive charges within 5 milliseconds. The tower sequencers simultaneously apply power to the tower jettison motor squibs. The entire launch escape assembly is released and pulled clear of the C/M trajectory. Umbilical electrical connectors are disconnected automatically when the tower and C/M separate.

3-10. LAUNCH ESCAPE MOTOR. (See figure 2-1.)

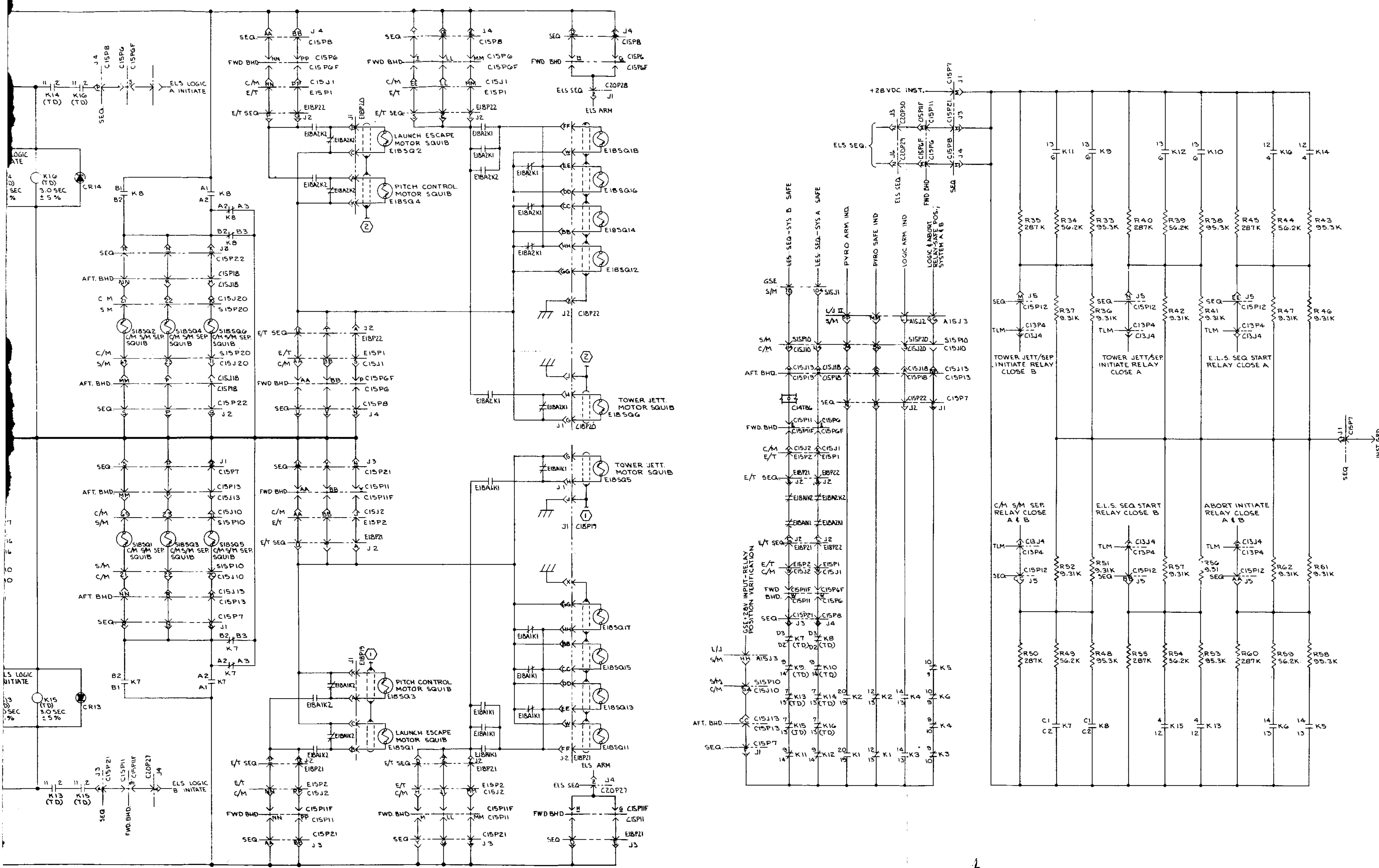
3-11. The launch escape motor supplies the thrust necessary to propel the escape vehicle along the abort trajectory. Passive thrust vector control provides a flight path that arcs slightly in the pitch-up direction. Variation in the throat diameters of the four exhaust nozzles is the method of flight vector control used. The operational characteristics of the motor are contained in table 3-3.

Table 3-3. Operational Characteristics of the Launch Escape Motor

Thrust (maximum)	140,000 pounds
Duration	8 seconds
Propellant	8-point star grain polysulfide ammonium perchlorate formulation



C14BT2
PYROTECHNIC BATTERY SYS. A
C14BT3
LOGIC BATTERY SYS. A
C14BT4
LOGIC BATTERY SYS. B
C14BT1
PYROTECHNIC BATTERY SYS. B
C14TB5 (VGP)
C14TB6 GRD BUS
PYRO BUS DEARM SYS A-GSE INPUT+28V
COMMON RETURN GSE NEG
LOGIC BUS DEARM SYS A-GSE INPUT+28V
ARM & DEARM PYRO BUS A
ARM & DEARM LOGIC BUS A
ARM & DEARM PYRO BUS B
ARM & DEARM LOGIC BUS B
GSE ARM PYRO BUS
GSE ARM LOGIC BUS
PYRO BUS DEARM SYS B-GSE INPUT+28V
COMMON RETURN GSE NEG
LOGIC BUS DEARM SYS B-GSE INPUT+28V
ABORT RESET GSE C/O
ABORT
ABORT RELAY SYS. A
ABORT RELAY SYS. B
ABORT RESET GSE C/O
ABORT
SEQ START SIGNAL A
SEQ START SIGNAL B
LOGIC BUS A INDICATE ARM
PL INDICATE ARM
D.C. VOLTAGE LOGIC BUS A
D.C. VOLTAGE PYRO BUS A
D.C. VOLTAGE LOGIC BUS B
D.C. VOLTAGE PYRO BUS B
LOGIC BUS B INDICATE ARM
PYRO BUS B INDICATE ARM
C/M-S/M SEP
E/T SEP & TWR JETT INITIATE
15.5 SEC. ±0.5
L.E.S. & PITCH CONTROL MTR. FIRE RELAY CLOSE A & B
TOWER JETT & SEP RELAY CLOSE A & B
MOTOR SWITCH RESET GSE 28VDC
R21 76.8K
R22 20K
R24 9.31K
R31 9.31K
R29 20K
R28 76.8K
R23 178K
R30 178K
R19 26.7K
R20 20K
R25 9.31K
R32 9.31K
R27 20K
R26 26.7K
R8 30.9K
R14 30.9K
R10 9.31K
R12 9.31K
R16 9.31K
R18 9.31K
R9 9.31K
R11 9.31K
R15 9.31K
R17 9.31K
R7 30.9K
R13 30.9K
R2 30.9
R4 9.31K
R3 9.31K
R1 30.9K
R86 2K
R84 2K
R83 2K
R85 2K
CR16
CR15
K17



2

3. BATT. MONITOR RESISTOR VALUES ARE OHMS ± 1 % ½ WATT (RN70C_ _ _ _F PER MIL-R-10509)
2. SIGNAL CONDITIONING RESISTOR VALUES ARE IN OHMS ± 1% ¼ WATT (RN65C_ _ _ _F PER MIL-R-10509)
1. LATCHING RELAYS SHOWN WITH "Y" COIL LAST ENERGIZED
NOTES: UNLESS OTHERWISE SPECIFIED

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Figure 3-2. Launch Escape System Schematic Diagram

Table 3-3. Operational Characteristics of the Launch Escape Motor (Cont)

Functional nozzle throat diameters:	
Both yaw axis nozzles	6.1 inches
+pitch axis nozzle	5.1 inches
-pitch axis nozzle	6.5 inches
Nozzle exit location plane	Common outboard
Nozzle centerline cant	35 degrees ±15 minutes
Angular deviation of resultant main thrust	2.75 degrees ±15 minutes in +Z direction
Angle between nominal thrust and motor centerlines	2 degrees, 45±15 minutes
Maximum resultant torque of self-induced roll from nozzle misalignment	130 foot-pounds
Thrust rise time	0 to 90 percent in 85±0.15 milliseconds

3-12. PITCH CONTROL MOTOR. (See figure 2-1.)

3-13. The pitch control motor is the primary passive thrust vector control device in the launch escape system; it provides the passive thrust to place the launch escape vehicle in the correct flight attitude for a successful escape. The pitch control motor is employed in unison with the launch escape motor. Firing the pitch control motor causes the nose of the launch escape vehicle to pitch over approximately 20 degrees; the operational characteristics of the motor are contained in table 3-4.

3-14. LAUNCH ESCAPE TOWER JETTISON MOTOR. (See figure 2-1.)

3-15. The launch escape tower jettison motor operates in conjunction with the tower release system to remove the expended launch escape system from the vicinity of the command module. The tower is cleared from the command module flight trajectory to preclude any interference with the earth landing sequence. Passive thrust vector control in the form of offset exhaust nozzles provides a trajectory that arcs slightly in the pitch-up direction. The operational characteristics of the motor are contained in table 3-5.

Table 3-4. Operational Characteristics of the Pitch Control Motor

Thrust	6,000 pounds
Duration	0.5 second
Propellant	14-point star grain polysulfide ammonium perchlorate formulation
Exhaust nozzle thrust angle	0 degree
Time required to reach 90 percent of maximum thrust	60 milliseconds
Thrust axis mean motor centerline	0 degree ±30 minutes in all planes

Table 3-5. Operational Characteristics of the Launch Escape Tower Jettison Motor

Thrust	33,000 pounds
Duration	1 second
Time required to reach 90 percent of maximum thrust	75 to 125 milliseconds
Angles between resultant thrust axis and motor:	
Pitch plane	2 degrees, 30 minutes in the +Z direction
Yaw plane	0 degree ±30 minutes

3-16. TOWER SEQUENCERS. (See figure 2-1.)

3-17. The tower sequencer consists of four motor switches, two electrical connectors, and associated wiring contained in a box type case. Each motor switch has several sets of contacts and is operated by a small 28-volt d-c motor. The motor moves the switch from the normally open to closed position before it is cut off. It may be reset to the normally open position by GSE by reversing the motor.

3-18. Switch K2 controls the launch escape motor squib circuits and the pitch control motor squib circuits. A normally closed set of contacts protects the squibs from spurious firing currents by forming closed loops of their firing circuits. When switch K2 is operated by the LES motor fire signal from the launch escape sequencer this set of contacts open and another set closes to permit 28 volt d-c power from the LES pyro bus to reach the launch escape motor squibs and the pitch control motor squibs to fire the motors.

3-19. Switch K1 controls the squib circuits for the tower jettison motor and the escape tower pyrotechnic bolts. A normally closed set of contacts protects the tower jettison motor squibs, and another set of contacts protects the pyrotechnic bolt squibs by forming closed loops of their firing circuits. When switch K1 is operated by the tower jettison motor signal from the launch escape sequencer, these sets of contacts open and other sets close to permit 28 volt d-c power from the tower jettison bus to reach the tower jettison motor squibs and escape tower pyrotechnic bolt squibs to fire the bolts and motor.

3-20. Other signals transmitted by the sequencer include GSE, telemetry, escape tower separation, and pyro bus arm.

3-21. LES SEQUENCE CONTROLLER. (See figures 2-7, 3-2, and 3-3.)

3-22. The LES sequence controller directs the timing and order of the electrically initiated steps in the abort sequence. Complete redundance of the entire sequencing network is provided for reliability. The sequencer is a standard switching logic device employing time delay relays. Table 3-6 identifies sequencer outputs as to time, function, controlling components, and output pin number.

Table 3-6. Launch Escape System Sequence Functions

Sequence Controller Signal	Function	Time	Controlling Component	Power Source
Pyro bus arm	Provides 28 volts for squibs	Prelaunch	K2, K1*	C15J22v, C15J22u*
Logic bus arm	Provides 28 volts for sequencer logic bus	Prelaunch	K4, K3*	C15J22m, C15J7m*
C/M-S/M separation system arm	Provides 28 volts for squibs	Prelaunch	K4, K8, K3*, K7*	C15J22m, C15J7m*
Tower release system arm	Provides 28 volts for squibs	Prelaunch	K4, K10, K12, K3*, K9*, K11*	C15J22m, C15J7m*
Fire C/M-S/M separation squibs	Detonate tension tie pyrotechnic cutting charges to release C/M-S/M	Abort command	K6, K8, K5*, K7*	C15J22r, C15J7r*
Fire launch escape motor and pitch control motor	Close tower sequencer motor switch K2	Abort command	K6, K5*	C15J22m, C15J7m*
Start 15.5 second time delay relay	Delayed escape tower separation and jettison motor ignition	Abort command	K6, K5*	C15J22m, C15J7m*
Fire escape tower bolts and jettison motor	Close tower sequencer motor switch K1	Abort command plus 15.5 seconds	K10, K12, K9*, K11*	C15J22r, C15J7r* C15J22m, C15J7m*

Table 3-6. Launch Escape System Sequence Functions (Cont)

Sequence Controller Signal	Function	Time	Controlling Component	Power Source
ELS logic initiate	Start 3.0 second time delay relay	Abort command plus 15.5 seconds	K10, K12, K9* K11*	C15J22m, C15J7m*

* Denotes redundant circuit

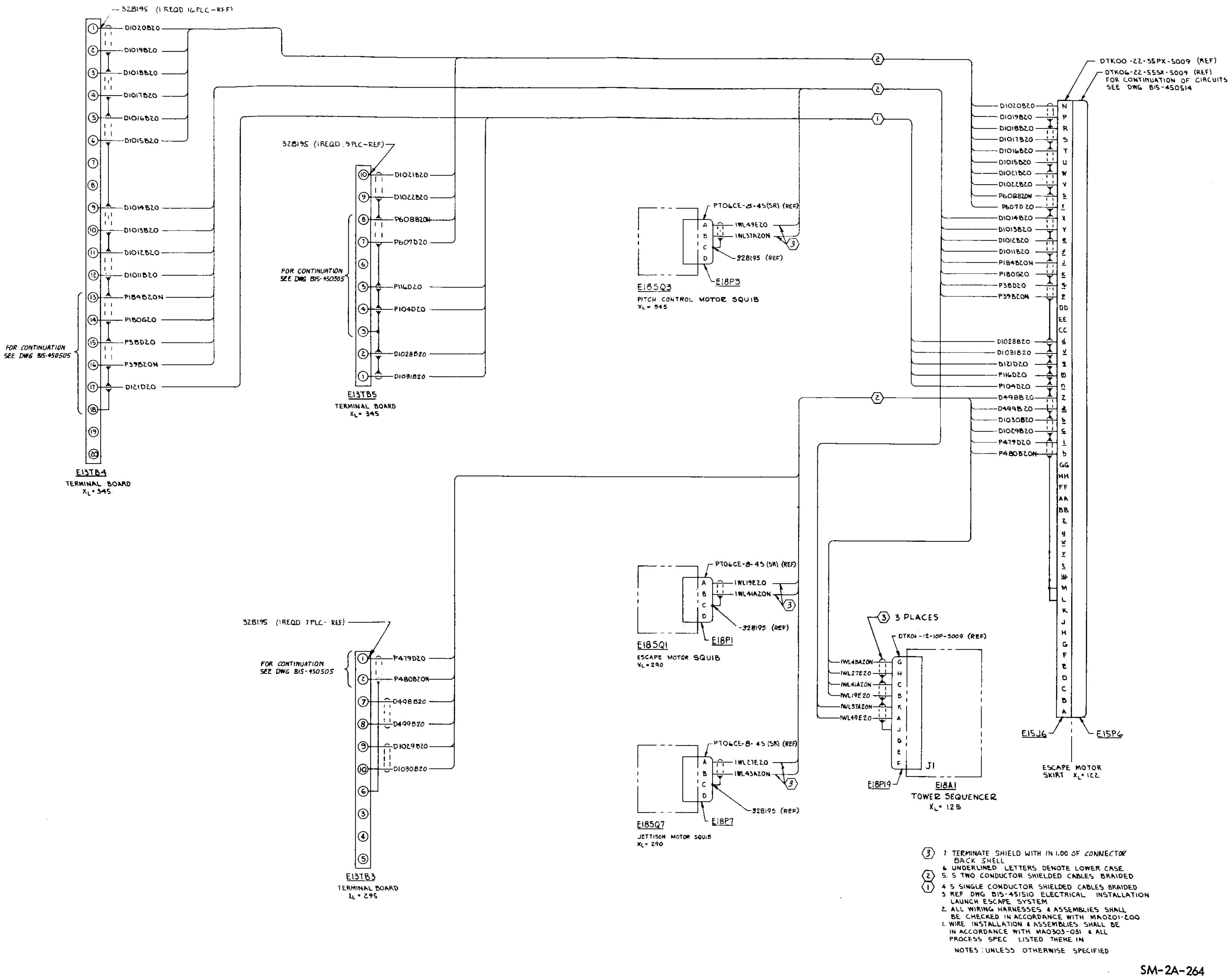

Figure 3-3. Launch Escape System Wiring Diagram (Sheet 1 of 8)

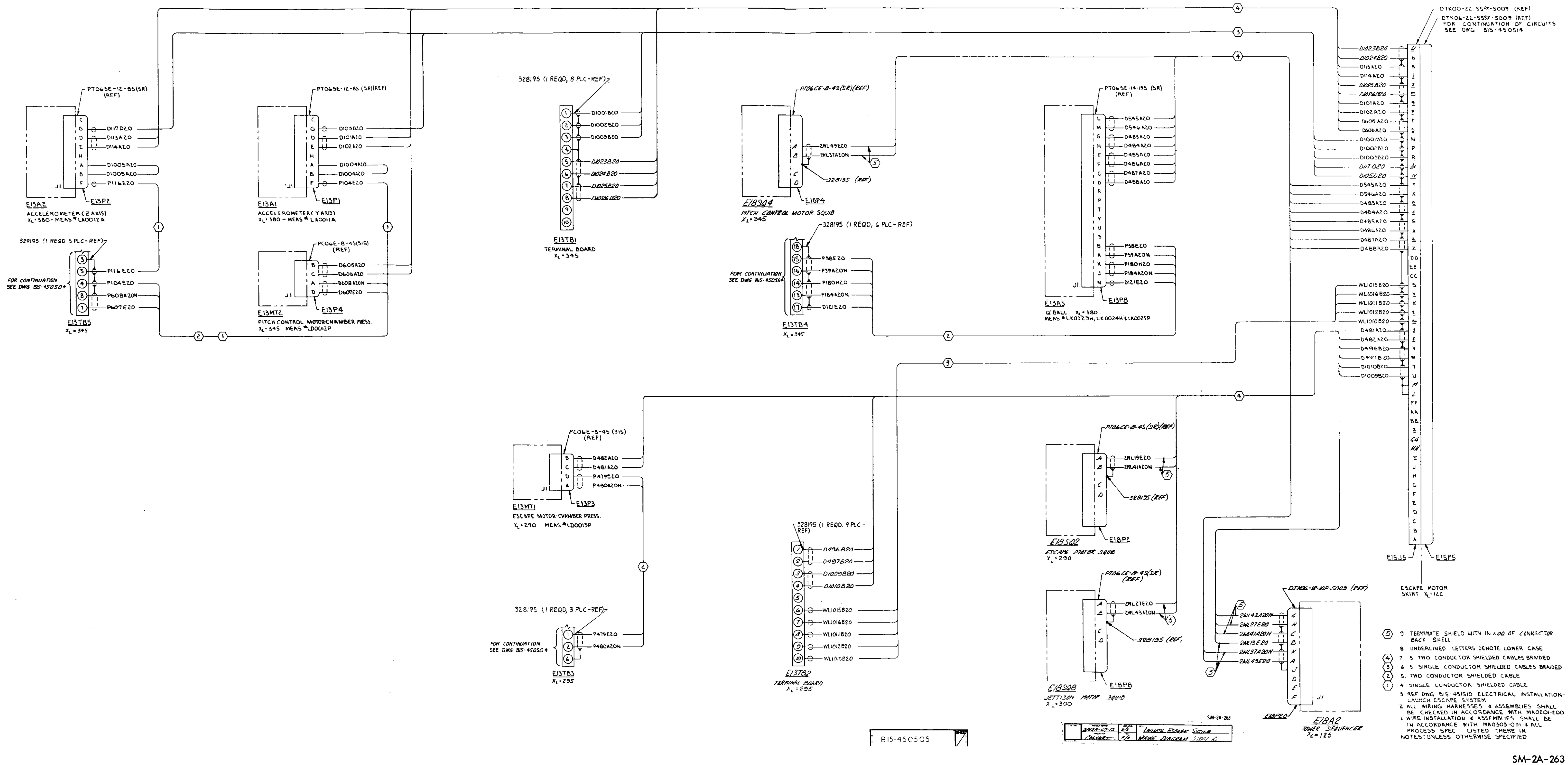

Figure 3-3. Launch Escape System Wiring Diagram (Sheet 2 of 8)

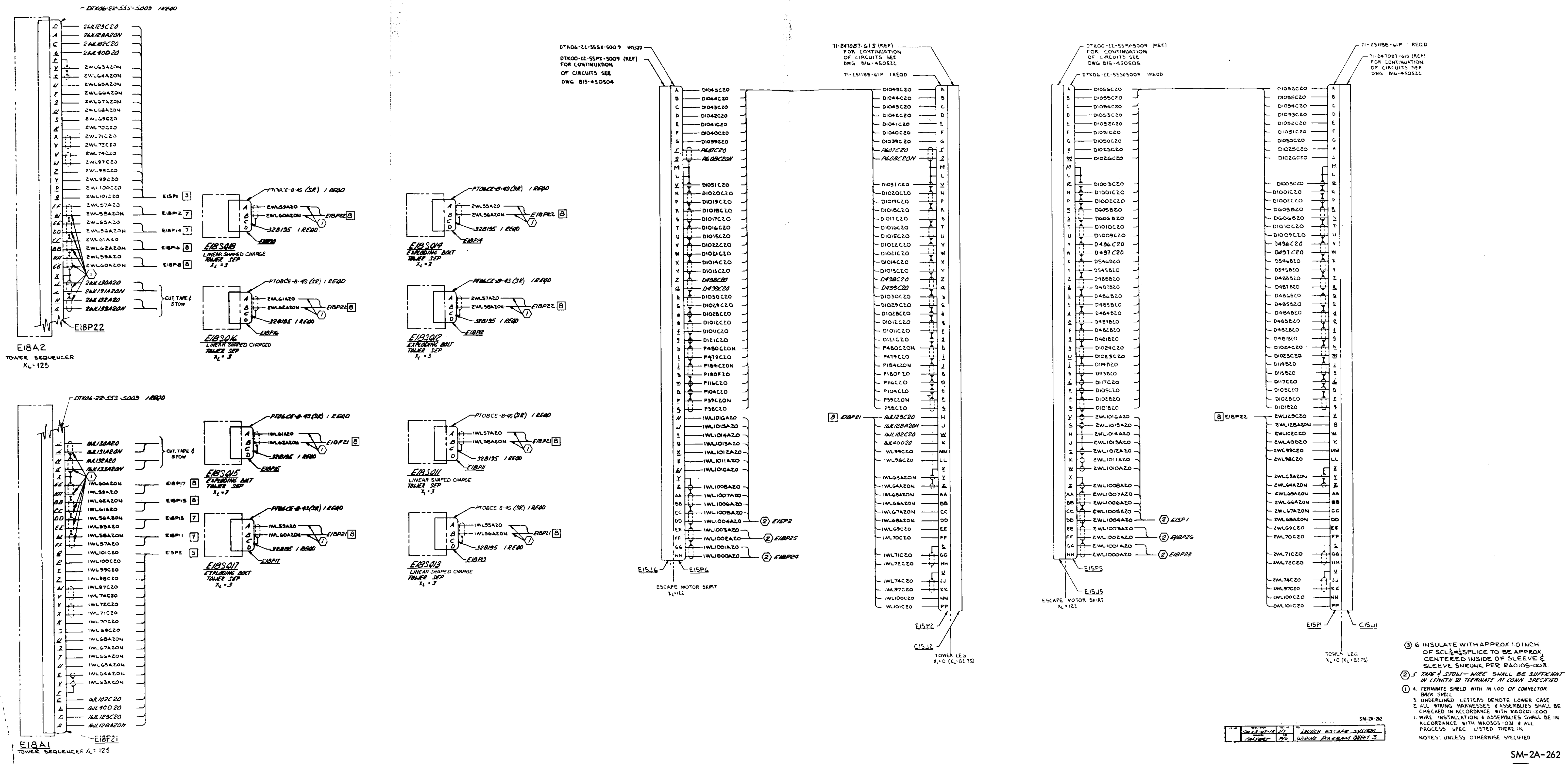

Figure 3-3. Launch Escape System Wiring Diagram (Sheet 3 of 8)

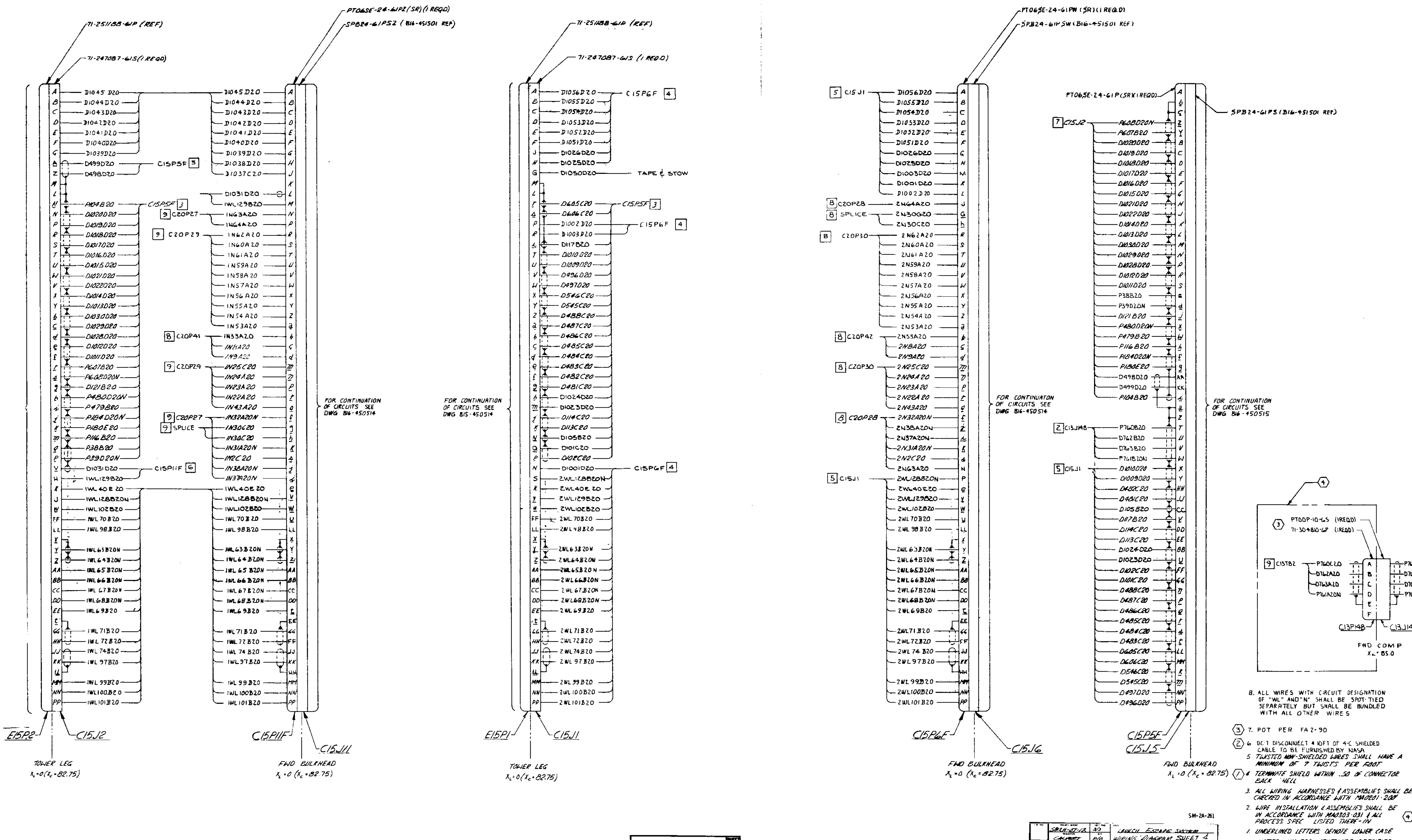

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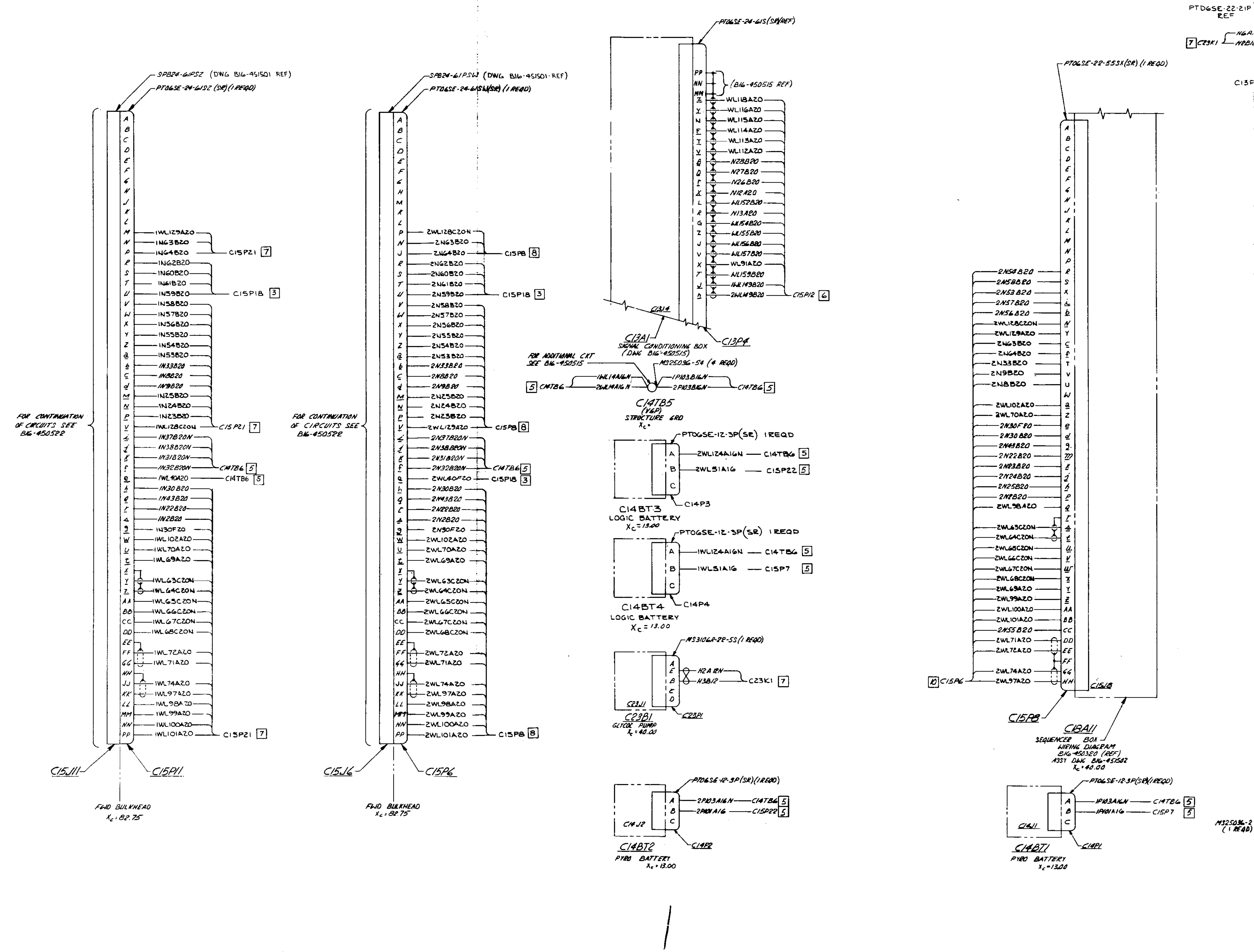
Figure 3-3. Launch Escape System Wiring Diagram (Sheet 4 of 8)



SPB24-61PSZ (DWG B16-451501 REF)
PTO6SE-24-61SZ (SR)(1 REQD)
FOR CONTINUATION OF CIRCUITS SEE B16-450522
C15P21 7
C15P18 3
C14TB6 5
C15J11
C15P11
FWD BULKHEAD
Xc=82.75
SPB24-61PSW (DWG B16-451501-REF)
C15P8 8
C15J6
C15P6
PTO6SE-24-61S(SR/REF)
(B16-450515 REF)
C15P12 6
C13A1
SIGNAL CONDITIONING BOX
(DWG B16-450515)
C13P4
FOR ADDITIONAL CKT SEE B16-450515
MS25036-54 (4 REQD)
C14TB5
(Y&P)
STRUCTURE GRD
PTO6SE-12-3P(SR) 1 REQD
C14P3
C14BT3
LOGIC BATTERY
Xc=13.00
C14P4
C14BT4
LOGIC BATTERY
Xc=13.00
MS3106R-22-5S(1 REQD)
C23K1 7
C23J1
C23P1
C23B1
GLYCOL PUMP
Xc=40.00
PTO6SE-12-3P(SR)(1 REQD)
C14J2
C14P2
C14BT2
PYRO BATTERY
Xc=13.00
PTO6SE-22-21P
REF
PTO6SE-22-55SX(SR) (1 REQD)
10 C15P6
C15P8
C15J8
C18A11
SEQUENCER BOX
WIRING DIAGRAM
B16-450320 (REF)
ASSY DWG B16-451562
Xc=40.00
C14J1
C14P1
C14BT1
PYRO BATTERY
Xc=13.00

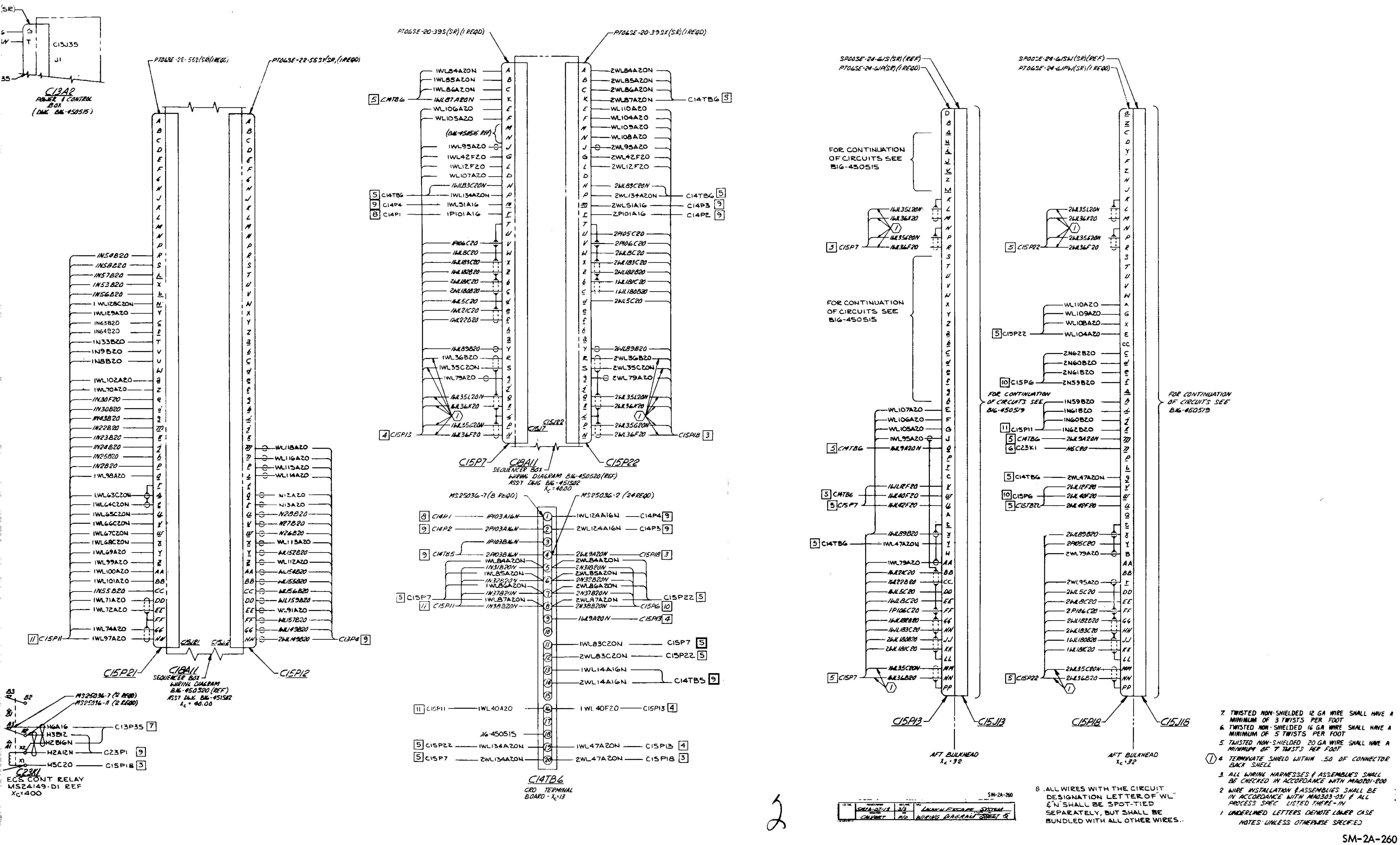
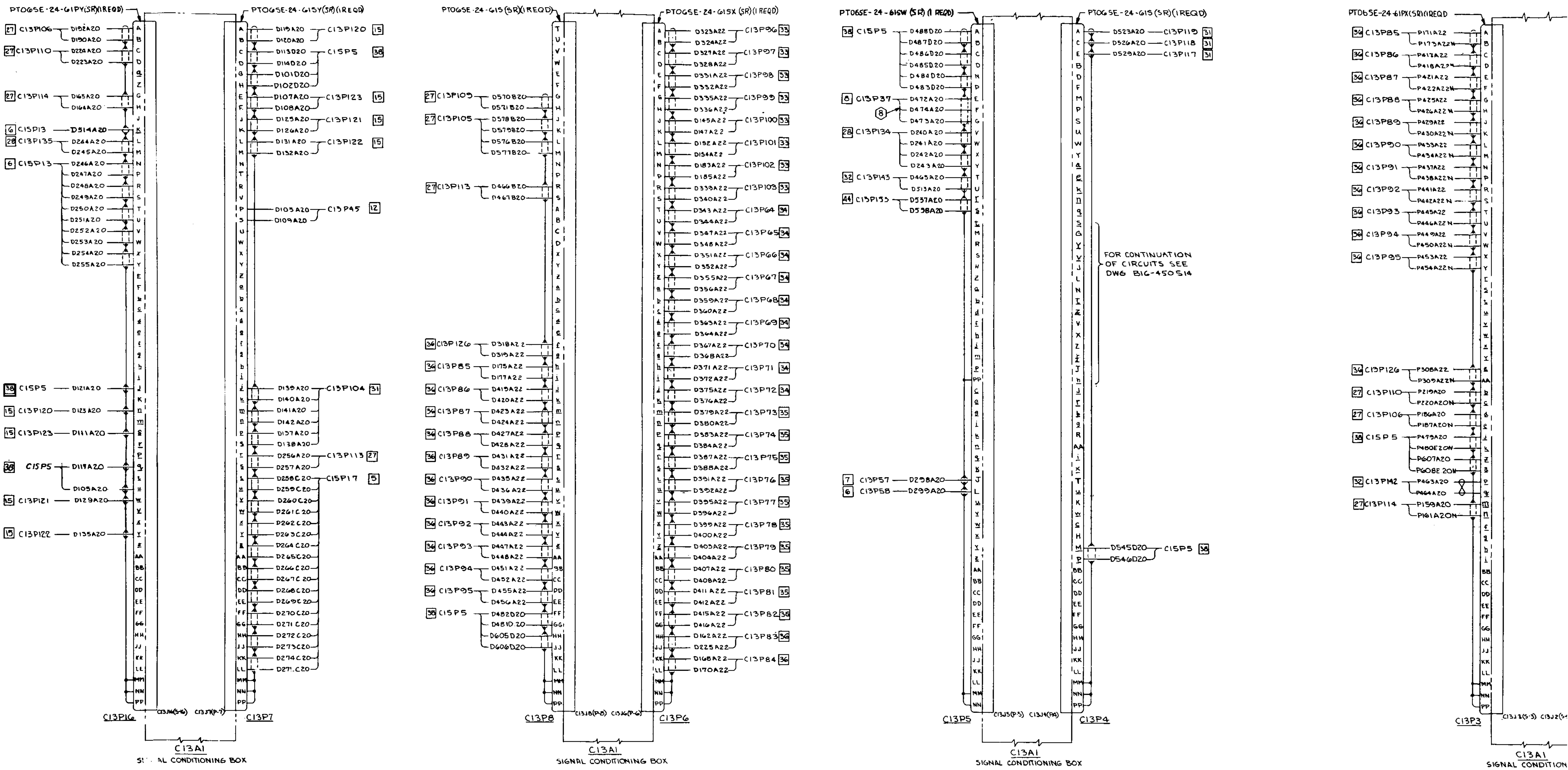


Figure 3-3. Launch Escape System Wiring Diagram (Sheet 5 of 8)


PTO6SE-24-61PY(SR)(1REQD)
PTO6SE-24-61SY(SR)(1REQD)
C13P16
C13P7
C13A1
PTO6SE-24-61S(SR)(1REQD)
PTO6SE-24-61SX(SR)(1REQD)
C13P8
C13P6
C13A1
SIGNAL CONDITIONING BOX
PTO6SE-24-61SW(SR)(1REQD)
PTO6SE-24-61S(SR)(1REQD)
FOR CONTINUATION OF CIRCUITS SEE DWG B1G-450514
C13P5
C13P4
C13A1
SIGNAL CONDITIONING BOX
PTO6SE-24-61PX(SR)(1REQD)
C13P3
C13A1

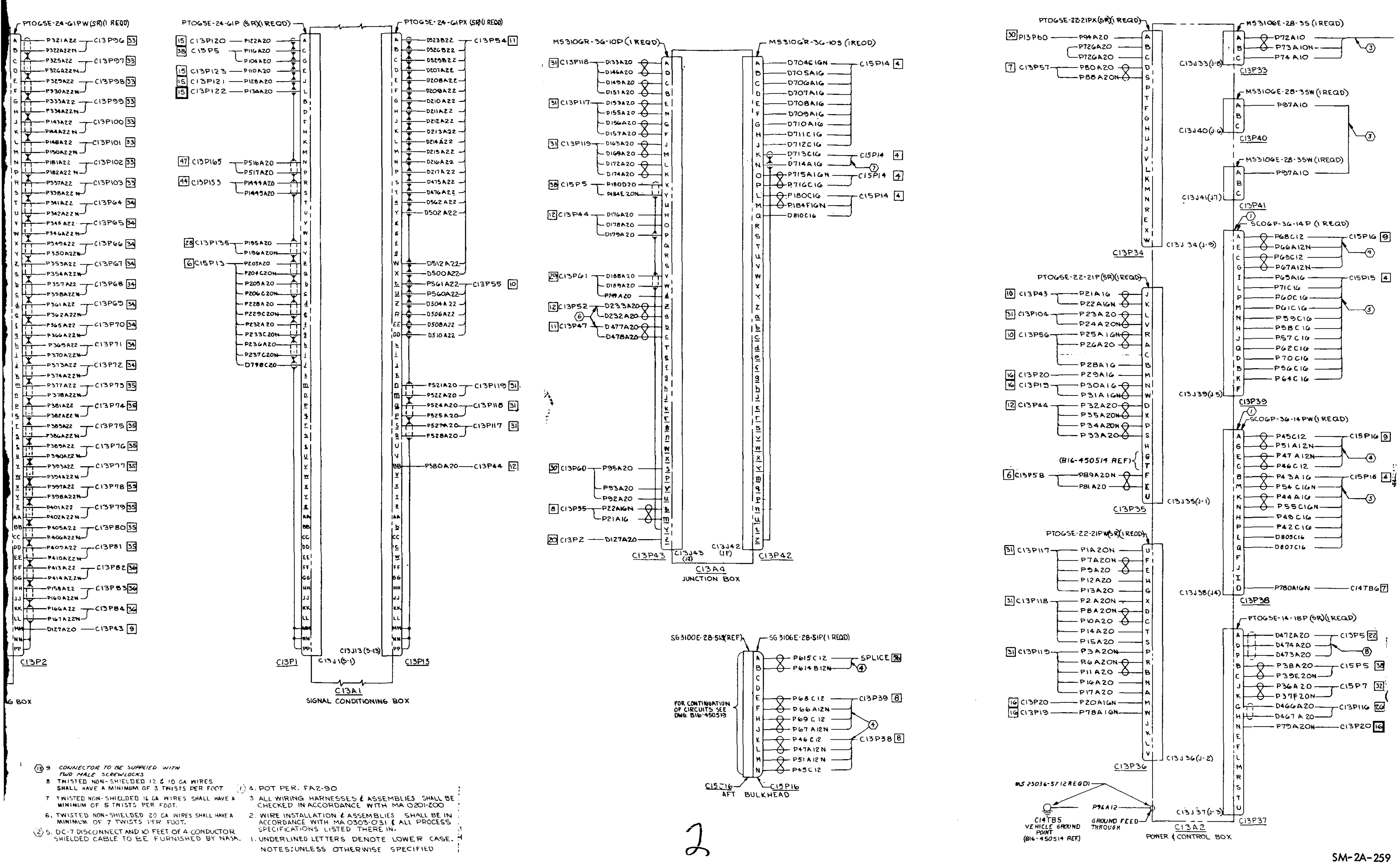
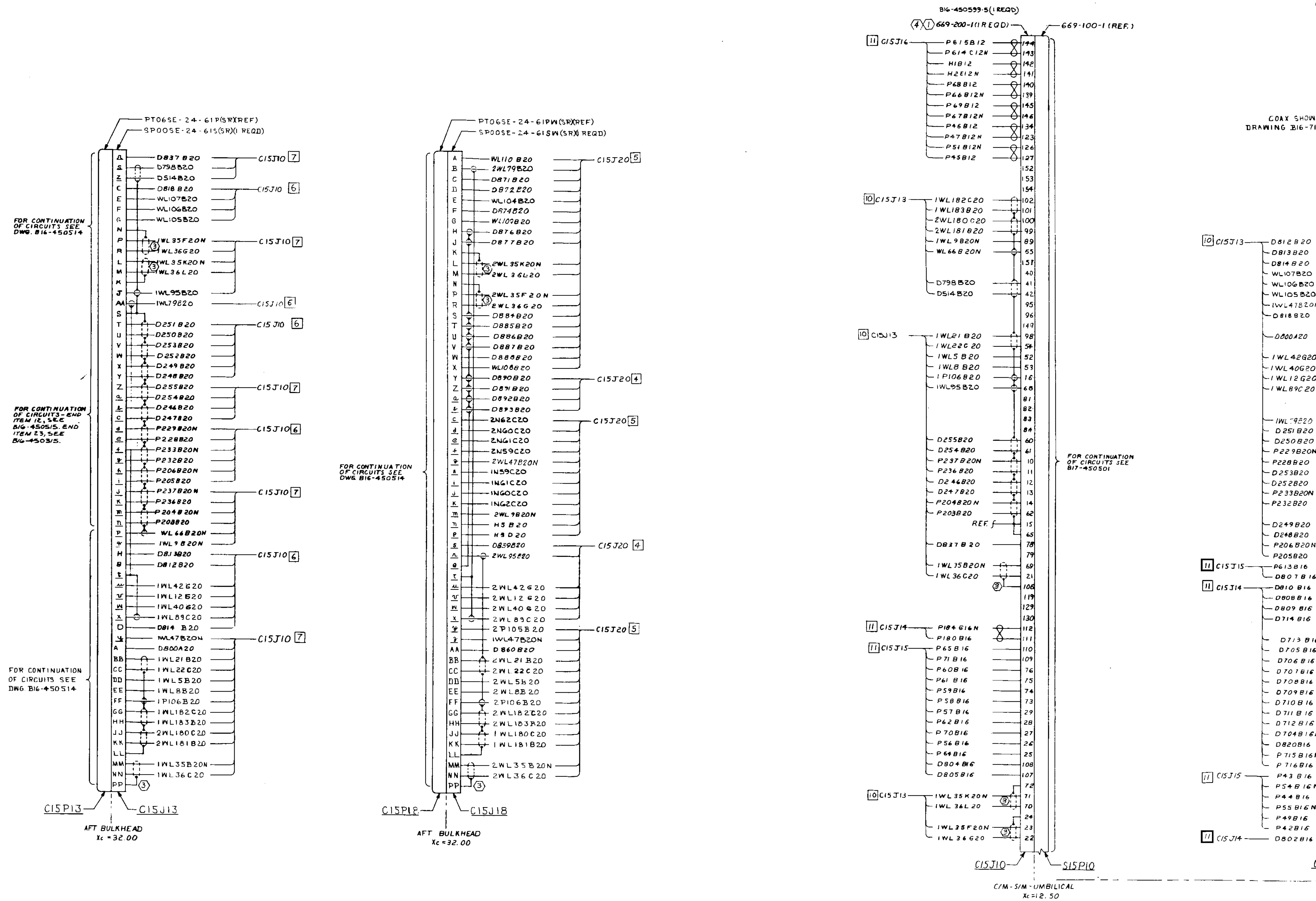


Figure 3-3. Launch Escape System Wiring Diagram (Sheet 6 of 8)



PT06SE-24-61P(SR)(REF)
SP00SE-24-61S(SR)(1 REQD)
FOR CONTINUATION OF CIRCUITS SEE DWG. B16-450514
FOR CONTINUATION OF CIRCUITS - END ITEM 12, SEE B16-450515. END ITEM 23, SEE B16-450315.
FOR CONTINUATION OF CIRCUITS SEE DWG B16-450514
C15J10 7
C15J10 6
C15P13
C15J13
AFT BULKHEAD
Xc = 32.00
PT06SE-24-61PW(SR)(REF)
SP00SE-24-61SW(SR)(1 REQD)
FOR CONTINUATION OF CIRCUITS SEE DWG B16-450514
C15J20 5
C15J20 4
C15P18
C15J18
AFT BULKHEAD
Xc = 32.00
B16-450599-5(1 REQD)
4 1 669-200-1(1 REQD)
669-100-1 (REF.)
11 C15J16
10 C15J13
11 C15J14
11 C15J15
FOR CONTINUATION OF CIRCUITS SEE B17-450501
C15J10
S15P10
C/M - S/M - UMBILICAL
Xc = 12.50
COAX SHOWN
DRAWING B16-7

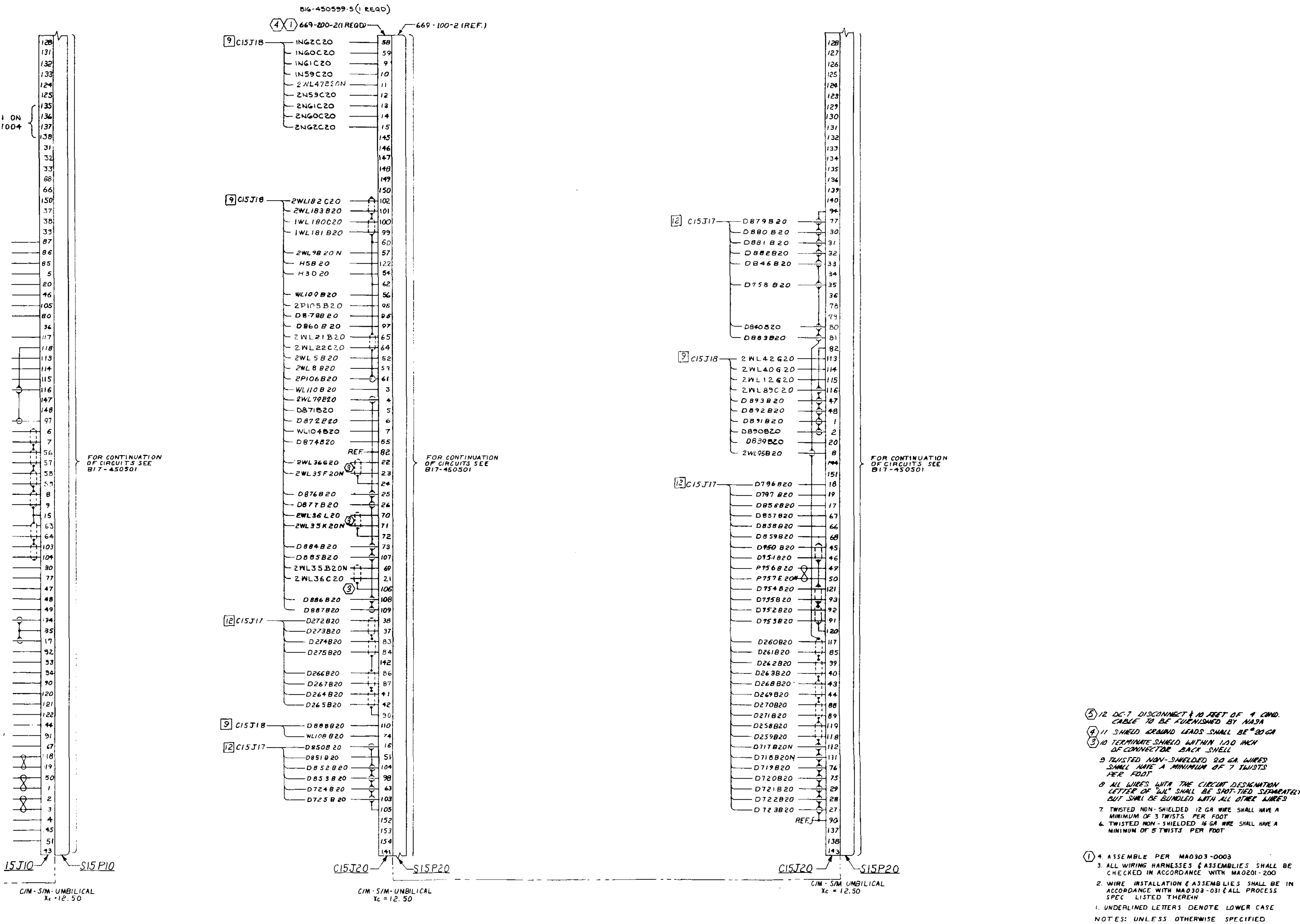


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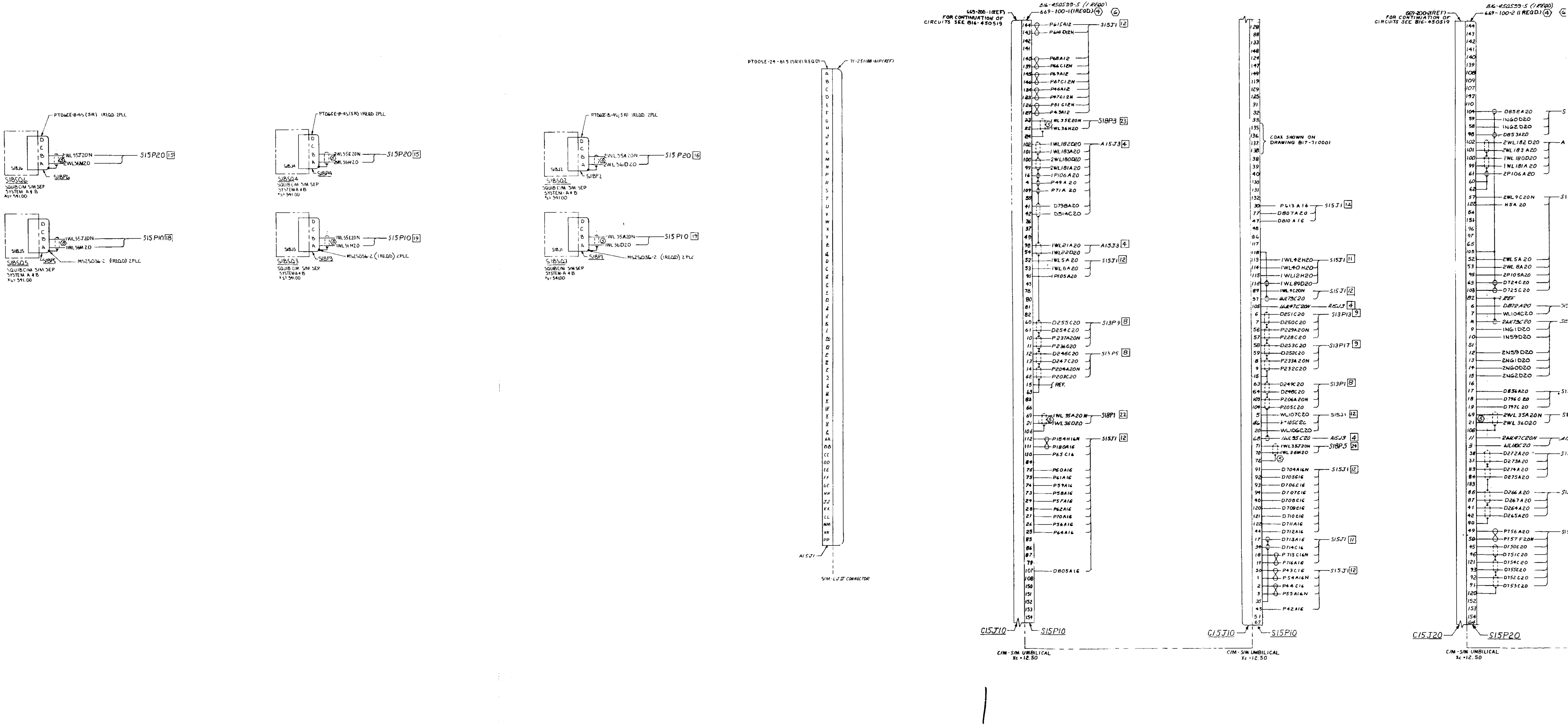
Figure 3-3. Launch Escape System Wiring Diagram (Sheet 7 of 8)



S18SQ6
S18SQ4
S18SQ2
S18SQ5
S18SQ3
S18SQ1
S15P20 15
S15P20 16
S15P10 18
S15P10 19
MS25036-2 (1REQD) 2PLC
A15J1
S/M-LJ II CONNECTOR
FOR CONTINUATION OF CIRCUITS SEE B16-450519
669-100-1(1REQD)
B16-450599-5 (1 REQD)
COAX SHOWN ON DRAWING B17-710001
C15J10
S15P10
C15J20
S15P20
C/M-S/M UMBILICAL Xc=12.50

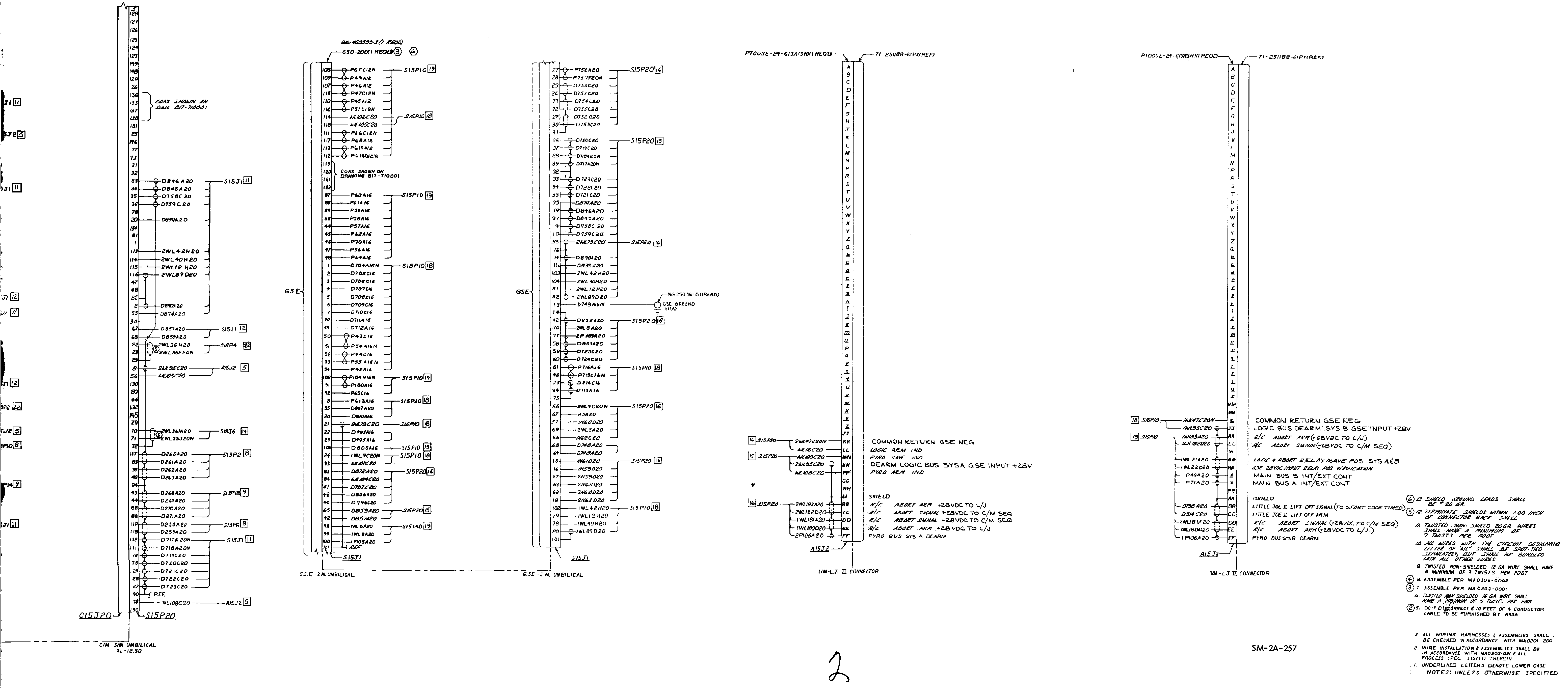


Figure 3-3. Launch Escape System Wiring Diagram (Sheet 8 of 8)

SECTION IV

EARTH LANDING SYSTEM

4-1. PURPOSE.

4-2. This prototype system, shown in figure 2-10, serves to qualify the basic design and engineering concepts of the earth landing system to be used throughout the Apollo program. The purpose of the production type earth landing system is to land the Apollo spacecraft command module safely after normal entry or a mission abort.

4-3. OPERATIONAL DESCRIPTION.

4-4. The boilerplate 12 earth landing system operates in a series of controlled steps commencing during flight immediately following jettison of the launch escape tower. Figure 4-1 is a functional block diagram showing the time sequence of pertinent events, and table 4-1 contains a time history of these events.

Table 4-1. Boilerplate 12 ELS Time History of Test Events

Time After Launch (sec)	Event
T + 44.5	Escape tower jettison
T + 47.5	Start recovery sequence controller. Forward heat shield jettison. Start 1.0 second time delay relay. Start 5.0 second time delay relay.
T + 48.5	Drogue parachute deployed by mortar.
T + 83.5	Closure of 15,000 feet baroswitches. Drogue parachute disconnect. Pilot parachutes deployed by mortar. Start 20.0 second time delay relay.
T + 87.5	Main parachutes inflated to reefed condition.
T + 91.5	Main parachutes reefing lines cut.

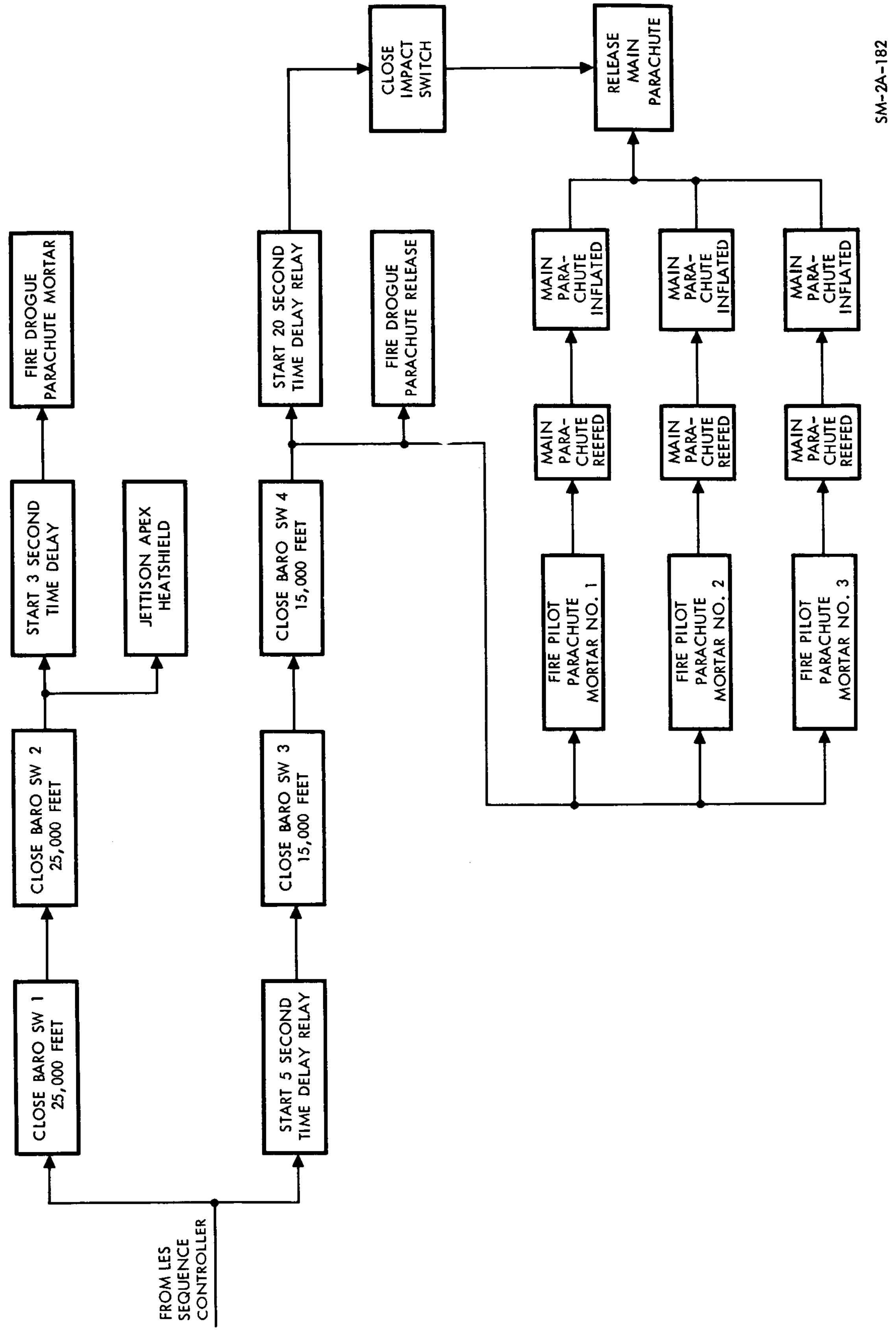


Figure 4-1. Earth Landing System Functional Block Diagram

Table 4-1. Boilerplate 12 ELS Time History of Test Events (Cont)

Time After Launch (sec)	Event
T + 95.5	Main parachutes fully inflated. Descent rate stabilized at 24 feet per second.
T + 103.5	Arm impact switches.
T + 465	Command module impact. Main parachutes released.

4-5. The sequence of events cannot be interchanged, speeded up, or delayed in flight. The only variable is wind condition, which will effect the location of the command module with respect to the launch pad. Table 4-2 contains the flight parameters.

Table 4-2. WSMR Flight Parameters Under Vertical Launch and No-wind Condition

Flight Sequence	Time After Launch Seconds	Altitude Feet MSL	Range Feet	Velocity Feet per Second	Flight Path Angle Degrees
Tower jettison	T + 44.5	24,000	19,500	476	±2.4
Drogue chute deployment	T + 48.5	23,800	21,200	371	-13.6
Main chute deployment	T + 83.5	15,000	24,500	275	-90.0
Command module impact	T + 465	4,000	25,000	24	-90.0

4-6. The earth landing system is initiated by a 28-volt dc signal received from the launch escape system sequence controller after the launch escape tower has been jettisoned. The earth landing sequence of events is controlled by the earth landing system sequence controller. The forward heat shield is ejected three seconds after ignition of the launch escape system jettison motor. One second after forward heat shield jettison, the drogue parachute will be deployed to position the command module in the proper attitude and provide initial descent deceleration for main parachute deployment. When the command module has descended to 15,000 feet, the 15,000-feet baroswitches close, the drogue chute is released, and three pilot parachutes are deployed. The pilot parachutes extract the three main parachutes which are inflated in a reefed condition to reduce the opening shock. After a 6 second time delay, the parachutes are disreefed and fully inflated. The main parachutes slow the descent rate of the command module to approximately 24 feet per second. The main parachutes are automatically released from the command module upon earth impact. Figures 4-2 and 4-3 are the earth landing system schematic and wiring diagrams, respectively.

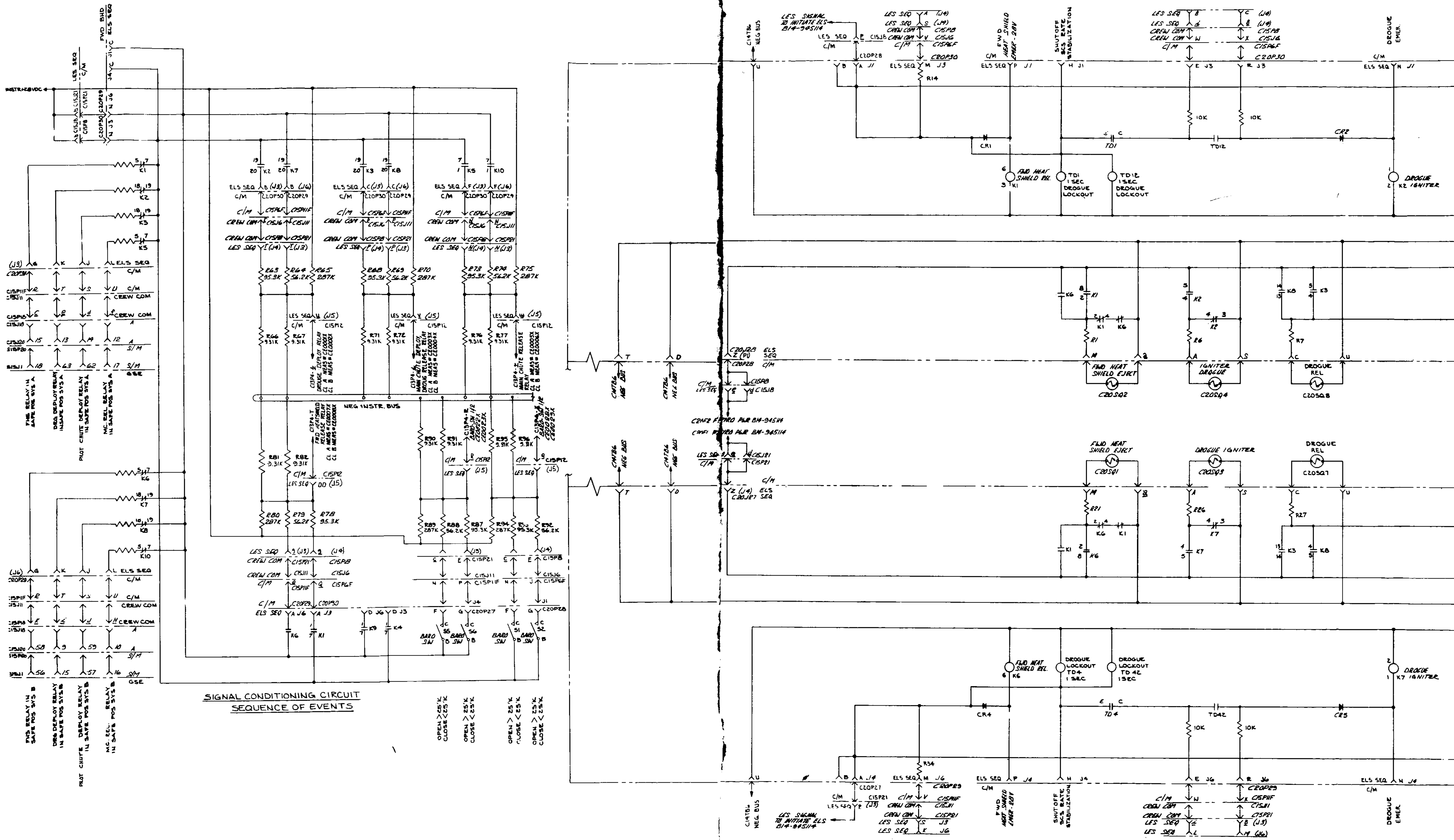
4-7. PARACHUTE SYSTEM. (See figures 2-10 and 4-1.)

4-8. The parachute system is used to decelerate the command module through a series of controlled steps to a safe landing velocity. The parachute system consists of the drogue parachute subsystem, the pilot parachute subsystem, the main parachute pack assemblies, and the main cluster disconnect and harness assemblies.

4-9. DROGUE PARACHUTE SUBSYSTEM. The drogue parachute assists the free-falling command module in assuming its normal descending attitude, which is blunt-end forward. This is the favorable attitude for main parachute deployment. A signal from the sequence controller fires the cartridges in the drogue mortar. The mortar ejects the drogue parachute which is contained in a protective deployment bag. The protective bag assists in parachute deployment after ejection. The parachute is streamlined to the limit of the riser length and inflated. The riser is of sufficient length to permit the parachute to clear the airflow about the command module. The drogue parachute is released when the command module descends to 15,000 feet altitude. A disconnect signal fires the cartridge in the drogue parachute disconnect assembly when the 15,000-feet baroswitches close.

4-10. PILOT PARACHUTE SUBSYSTEM. Each of the three pilot parachutes deploy one of the main parachutes. The signal for deployment of the three pilot parachutes is simultaneous with the drogue chute release signal. The cartridge is fired in the pilot mortar to deploy the pilot chutes. The pilot chutes are contained in protective bags to help in parachute deployment after ejection. The parachutes are streamlined to the limit of their riser lengths and then inflated. To deploy the main parachutes, a force is transmitted to the main parachute pack assemblies through the connecting risers.

4-11. MAIN PARACHUTE PACK ASSEMBLIES. The main parachutes lower the command module at an established rate of descent until earth impact; two of the main parachutes are capable of maintaining a safe rate of descent. The three main parachutes are simultaneously pulled clear of their protective bags and streamlined to the limit of their riser lengths. The risers are of sufficient length to clear the airflow about the command module. The initial opening of the main parachutes is held in a reefed state for six seconds to reduce the force



SIGNAL CONDITIONING CIRCUIT
SEQUENCE OF EVENTS

1

2

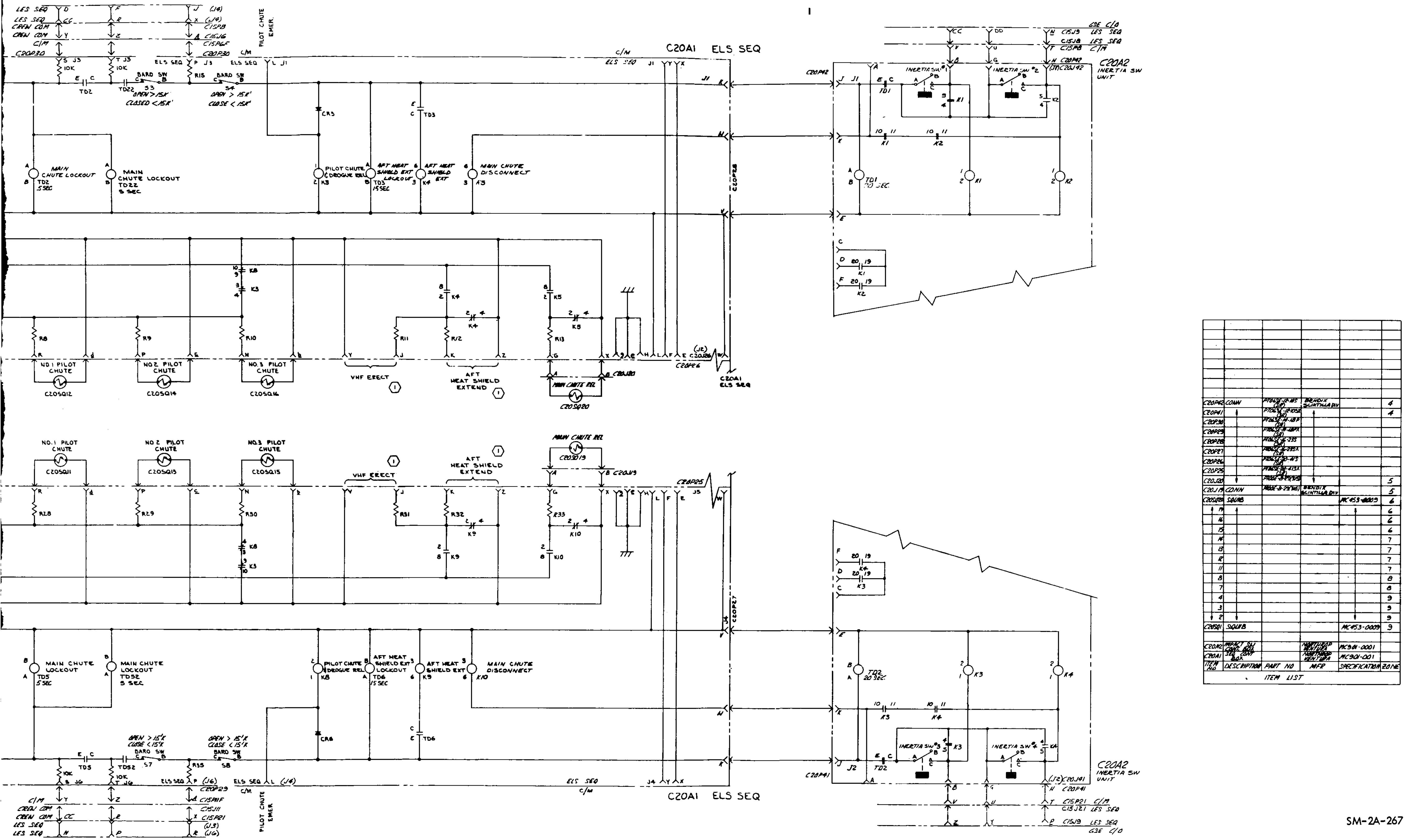
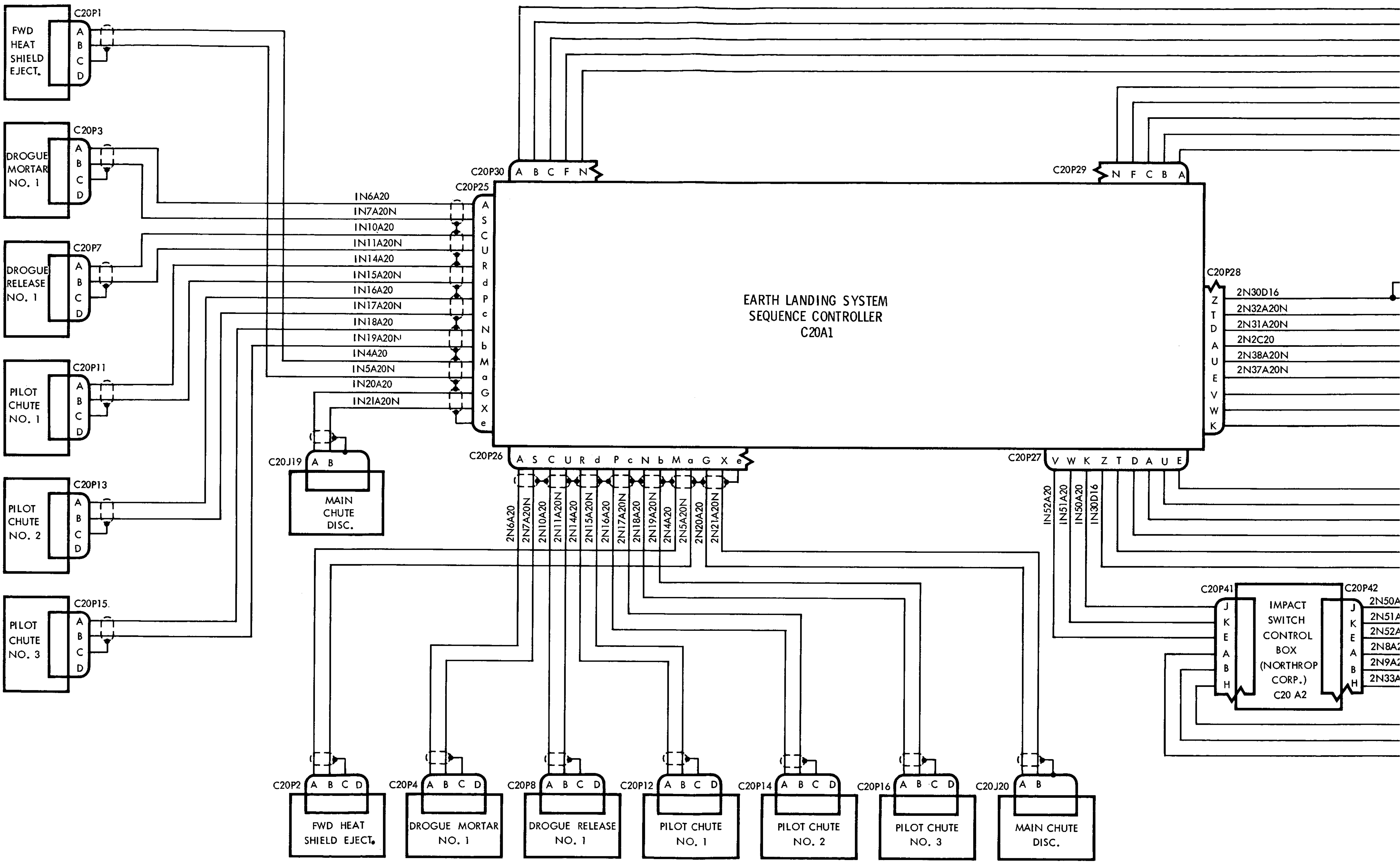


Figure 4-2. Earth Landing System Schematic Diagram



EARTH LANDING SYSTEM
SEQUENCE CONTROLLER
C20A1
FWD HEAT SHIELD EJECT.
C20P1
DROGUE MORTAR NO. 1
C20P3
DROGUE RELEASE NO. 1
C20P7
PILOT CHUTE NO. 1
C20P11
PILOT CHUTE NO. 2
C20P13
PILOT CHUTE NO. 3
C20P15
MAIN CHUTE DISC.
C20J19
C20P30
C20P25
C20P29
C20P28
C20P26
C20P27
1N6A20
1N7A20N
1N10A20
1N11A20N
1N14A20
1N15A20N
1N16A20
1N17A20N
1N18A20
1N19A20N
1N4A20
1N5A20N
1N20A20
1N21A20N
2N30D16
2N32A20N
2N31A20N
2N2C20
2N38A20N
2N37A20N
2N6A20
2N7A20N
2N10A20
2N11A20N
2N14A20
2N15A20N
2N16A20
2N17A20N
2N18A20
2N19A20N
2N4A20
2N5A20N
2N20A20
2N21A20N
1N52A20
1N51A20
1N50A20
1N30D16
IMPACT SWITCH CONTROL BOX (NORTHROP CORP.) C20 A2
C20P41
C20P42
C20P2
FWD HEAT SHIELD EJECT.
C20P4
DROGUE MORTAR NO. 1
C20P8
DROGUE RELEASE NO. 1
C20P12
PILOT CHUTE NO. 1
C20P14
PILOT CHUTE NO. 2
C20P16
PILOT CHUTE NO. 3
C20J20
MAIN CHUTE DISC.

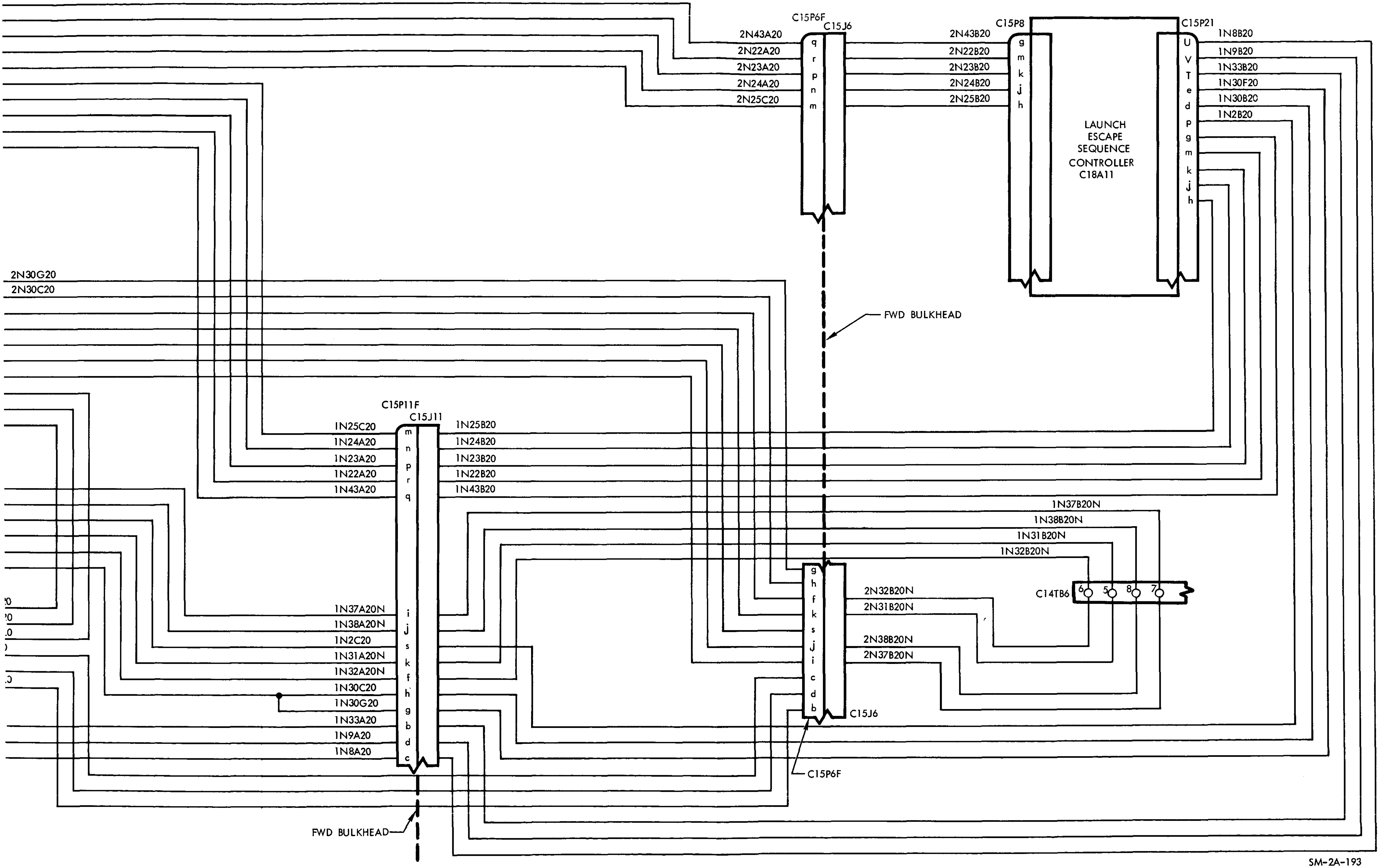


Figure 4-3. Earth Landing System Wiring Diagram

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of the opening shock upon the connection to the command module. The parachutes are fully opened when a timer initiates a cutting of the reefing restraints by a pyrotechnic method. Two reefing line cutters are used on each of the main chute reefing lines for redundancy. Arming is accomplished by pulling a pin when the chutes are deployed to the reefed condition to start the reefing line cutter timer.

4-12. MAIN CLUSTER DISCONNECT AND HARNESS ASSEMBLIES. The main cluster disconnect and harness assemblies provide a secure connection of the main parachute risers to the structure of the command module. They sustain the full weight of the command module during system operation. The main cluster disconnect assembly connects the three main parachute risers to the command module harness assembly. The harness attaches to the four parachute attach fittings on the command module. The main parachutes are disconnected at the main cluster disconnect pyrotechnically.

4-13. ELS SEQUENCE CONTROLLER. (See figures 2-10 and 4-2.)

4-14. The earth landing sequence controller contains time delay switches, relays, and baroswitches necessary to properly sequence the deployment and disconnect events of the earth landing sequence. The reliability of the controller, and subsequently of the system, is greatly insured by the complete redundancy of the entire sequencing network. Table 4-3 identifies sequencer function, time, controlling components, and output pin numbers.

4-15. FORWARD HEAT SHIELD RELEASE SYSTEM. (See figures 2-10 and 4-2.)

4-16. The forward heat shield serves as a protective cover for the parachutes and must be removed prior to parachute deployment. This is accomplished by the heat shield release system, which ejects the forward heat shield from the command module. The cartridges in the two gas generators are fired by the electrical signals from the ELS sequence controller. The burning cartridges ignite the gas generators, applying gas pressure to the ejector rods in the ejector cylinders. The force transmitted to the heat shield is sufficient to part the tension tie bolts and blow the heat shield clear of the command module.

Table 4-3. Earth Landing System Sequence Controller Functions

Signal Identification	Time of Event	Reference Designation of Control Components	Output Connections and Fins
Forward heatshield ejection	Tower jettison plus 1 second	K1 K6*	C20J28-M, -a C20J27-M*, -a*
Drogue chute deployment	Forward heat shield release plus 1 second	K2 K7*	C20J28-A, -S C20J27-A*, -S
Drogue chute release	15,000 foot baroswitch closure plus 5 seconds	S3, S4, TD2, TD22, K3 S7*, S8*, TD5*, TD52*, K8*	C20J28-C, -U C20J27-C*, -U*
No. 1 pilot chute deployment	Simultaneous with drogue chute release	S3, S4, TD2, TD22, K3 S7*, S8*, TD5*, TD52*, K8*	C20J28-R, -d C20J27-R*, -d*
No. 2 pilot chute deployment	Simultaneous with drogue chute release	S3, S4, TD2, TD22, K3 S7*, S8*, TD5*, TD52*, K8*	C20J28-P, -c C20J27-P*, -c*
No. 3 pilot chute deployment	Simultaneous with drogue chute release	S3, S4, TD2, TD22, K3 S7*, S8*, TD5*, TD52*, K8*	C20J28-N, -b C20J27-N*, -b*
Main chute release	Earth impact	Inertia switch #1 and #2 K1, K2 Inertia switch #3* and #4* K3*, K4*	C20J26-G, -X C20J25-G*, -X*

*Denotes redundant circuit.